SAE Journal

MARCH 1956

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FACTS

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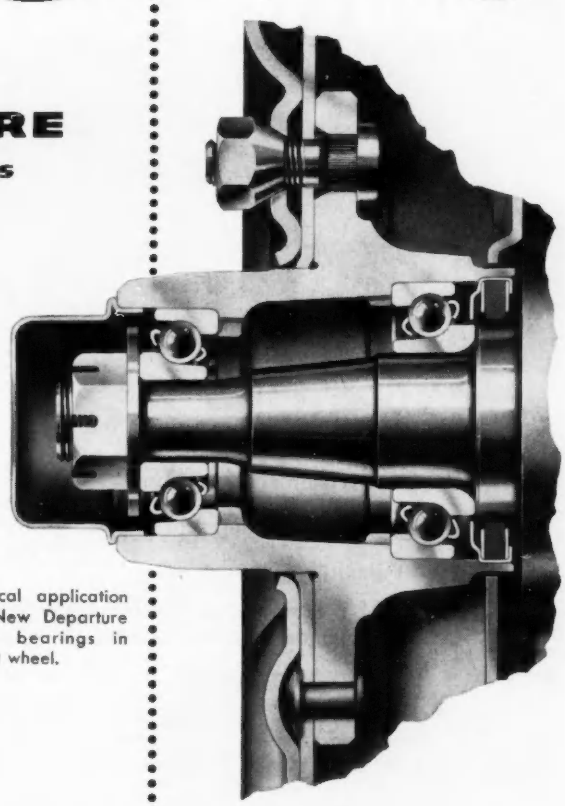

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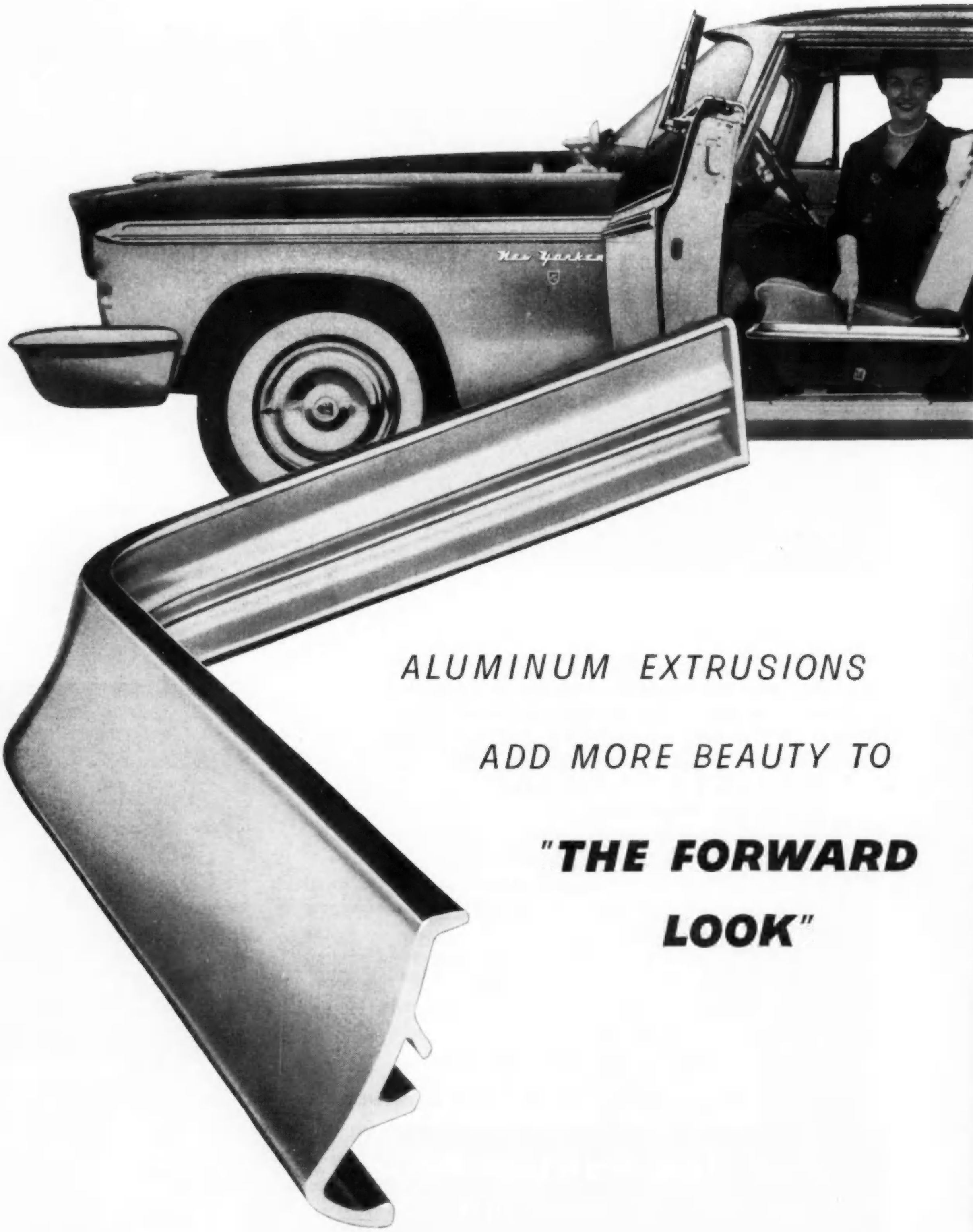
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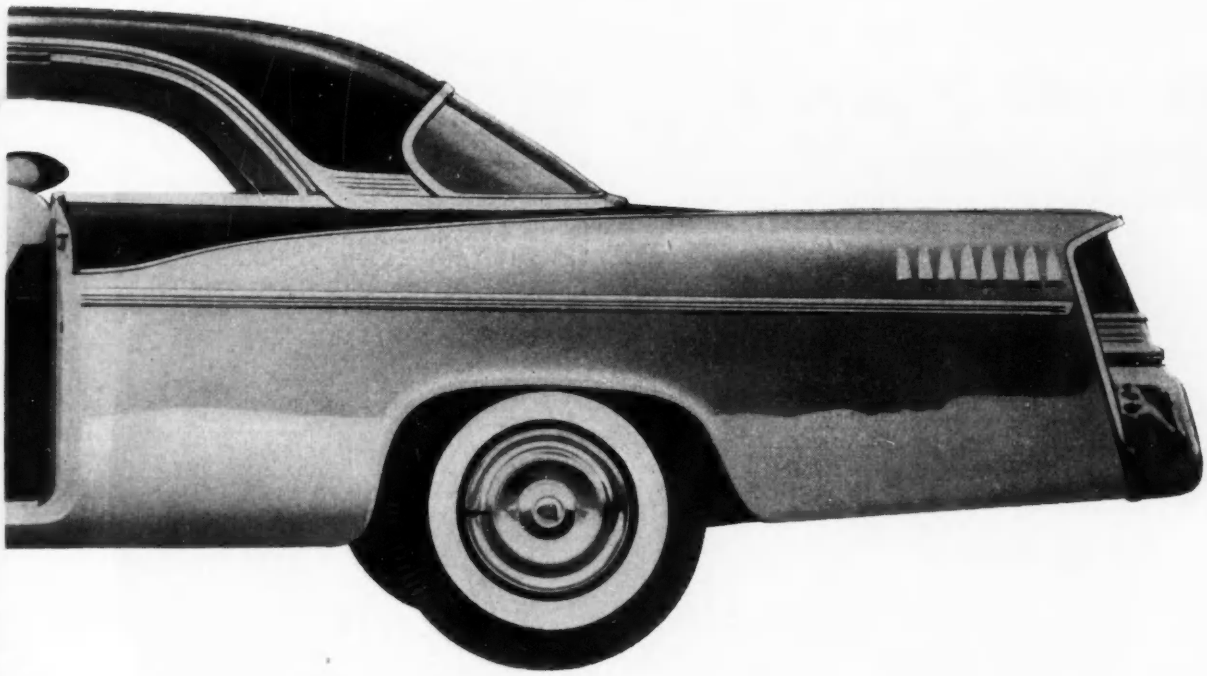

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For the Sake of Argument

Rewards . . .

By Norman G. Shidle

There's a good deal of truth in the saying that:

"We are rewarded not *for* what we do, but *by* what we do." In a certain sense we all get what we deserve. A paucity of pleasure accrues to the fellow who endures what he is doing, hoping for happiness after he gets through doing it. . . . What counts, as Grantland Rice has said, is "not that you won or lost—but how you played the game."

We spend most of our waking hours doing something. Only brief periods are devoted to satisfaction with accomplished ends. If we live chiefly for the interludes between efforts, we are truly alive only now and then.

Even more chancy is the hope that rewards from unpleasant work will bring release to something else. The pleasure most likely at the end of this road is that of the idiot who beat his head with a hammer: "Because it feels so good when I stop."

Unfortunate is the common tendency to equate "self-satisfied" with "smug." Satisfaction with one's self is the catalytic ingredient in any formula for happiness. Neither inner peace nor outward freedom comes to one dissatisfied with himself.

Lacking a healthy self-satisfaction, we are unlikely to be steadily buoyant in spirit. The man who knows he is "farmin' as well as he knows how" usually finds himself rewarded by what he is doing.

Rewards have a way of coming to us in kind. As Rufus Jones says: "The reward for being courteous and loving and sympathetic is that one is all the time growing more courteous and loving and sympathetic. . . . The prize that is won for the conquest of difficult problems in mathematics is the power to solve even more difficult ones. . . . It is 'the glory of going on'."

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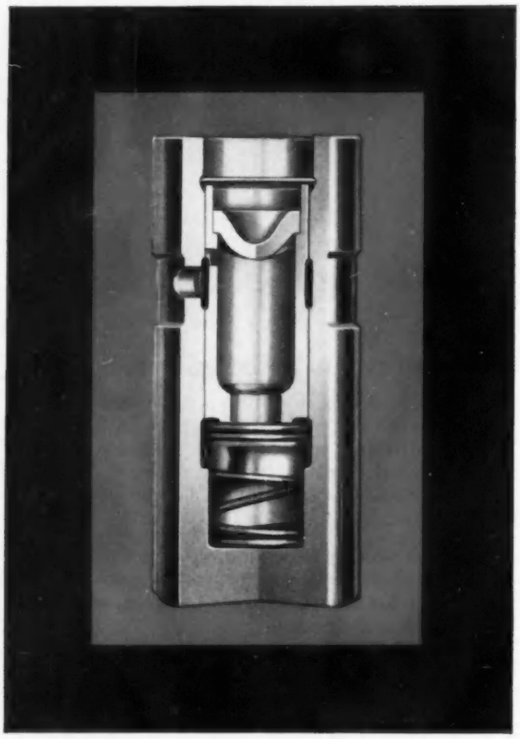

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Contents—March, 1956

Planning for Progress

Council-sparked study group to recommend Society changes to meet growing future needs.

by George A. Delaney
President, Society of Automotive Engineers

SAE Council recently took a long step forward to assure the best of everything for the Society in the years to come. In January, it set up a study program to find ways of equipping the Society best to adapt itself to changing and growing needs of automotive engineers . . . in short, Planning for Progress.

Council's action grows from its conviction that the Society's 50 years of solid achievement are the foundation for an even more brilliant future.

We're in an era of technological development that promises to change man's way of life beyond the wildest dreams of science fiction writers. Nuclear power, guided missiles, gas turbines, solar energy, machines with electronic brains, titanium . . . these are but a few new scientific areas that automotive engineers are trying to keep posted on, Dr. A. L. Klein, of Douglas Aircraft, recently told Council's Executive Committee. Already Society members are working in some of them.

By this Planning for Progress project, Council hopes to find out how to make SAE sufficiently flexible, to serve members and potential members, who have an increasing interest and participation in these new technical fields affecting automotive engineering.

It hopes, also, to facilitate deeper drilling and make possible bigger returns in its current areas of engineering interests.

Thinking on the project will stem from two basic concepts, Council believes:

1. That SAE's main reason for being is to develop, collect, and distribute technical information and ideas . . . by and for its members—in the areas of their technical interests. (This is indicated by the Society's Constitution.)
2. That 50 years of successful operation have produced traditions and policies which the next 50 years can use more of. The study will start with a listing of the good things in present operations which SAE needs more of.

Rubber Pigeon Holes

Past-President Rosen best expressed it when he said: "What we need in SAE are rubber pigeon holes rather than cast-iron ones. We need rubber ones to assimilate our rapidly-changing technology." The Society's present structure and modus operandi were conceived 25 years ago, and have served us well. Now, Council sees the time as ripe for another look. With an eye toward the future, we hope our study group will equip us with some of Past-President Rosen's "rubber-pigeon holes".

Council Takes Action

To implement its plans for this new look at the Society's structure, Council established by action at its January 13 meeting:

> "A study group . . . to investigate objectively the organization, functions, purposes and methods of SAE future activities; and, to bring back to Council recommendations for Council consideration and hoped-for adoption."

I visualize this group's mission as more than the mere creation of a blueprint for future SAE operations. In the development of its study, I hope it will establish a new climate, fresh attitudes and points of view among members and member groups attuned to the look ahead. Evolved in this spirit, the plans for progress, when eventually made ready for use, will fit comfortably like an old shoe.

I know, too, that this study group (why not call it the Planning for Progress Committee) will want to start with well-established bench marks. It will

search for ways of achieving Constitution-stated objectives, of preserving the rich traditions and practices of the past, of extending the member satisfactions and services of today.

It will seek to blend the already-established, time-tested SAE values with anticipated needs of the future. It will set its sights high on the quality of technical interchange. And it will furnish the Society with the equipment, and direction, and momentum beamed at an upward-moving target.

The committee will recognize that SAE functions best when it offers members opportunities to serve themselves, and each other, by processes that are comfortable and natural to them.

The Planning for Progress Committee will be launching its program on not completely uncharted waters, because such forward thinking already is under way in several SAE groups. Guideposts and "philosophies" have already been developed in several SAE areas, such as those for SAE Sections and Activity Committees. Other such guideposts are under way.

From these forward-looking, but isolated projects, I am sure the Planning for Progress Committee will draw guidance as to methods of approach to its own broader problems. From them, too, are almost certain to come specific concepts for integration in the hoped-for focus of all that is best in SAE tradition.

And so by Planning for Progress today, your Council is setting the stage for bridging yesterday's triumphs with the best-of-everything SAE traditions to serve the members of tomorrow.

Better Mileage, Fewer Failures . . .

. . . follow switch from mileage to condition-of-unit as guide to overhaul time. Results with engines paralleled with transmissions and differentials.

Based on paper by **E. B. Ogden**, Consolidated Freightways, Inc.

IT took a strike in an engine plant with a subsequent cutting off of parts supply to prove to us the advantage of running an engine without overhaul as long as it passes preventive maintenance inspection. During this emergency we found many engines operated from 60,000 to 80,000 miles beyond the top mileages we had formerly thought safe to set.

Our records show engine road failure frequency per mile dropped 45% when we abandoned top mileages, while average mileage per engine between overhauls rose 33%. We found the engines responsible for part of our lower average mileage were those which had had very low mileage since overhaul. This was due, of course, to errors made by mechanics in the assembly, and by the driver during the break-in period. In other words, fewer overhauls eliminated much of this hazard. But mainly, it was the removal of top mileages that made for mileage increase.

Having met with success with engines, top mileages were eliminated for transmissions and differentials shown in Table 1.

Table 1

	Average Miles Per Unit		
	Old Method	New Method	% Increase In Mileage
Transmissions	68,000	99,000	45
Differentials (One type)	111,000	153,000	38
Differentials (Second type)	88,000	113,000	28

Improvement has been shown in other units as well, but due to changing types of many units in the fleet, accurate comparison is difficult.

In many cases the difference between profit and loss can well be in the cost of equipment maintenance. Any maintenance program which is not designed and conducted to secure the utmost in mileage, with reasonable road failures, needs to be scanned with critical eye by management. (Paper "Reconditioning of Vehicle Components; Condition vs Mileage or Hours" was presented at SAE Annual Meeting, Detroit, Jan. 9, 1956. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Pre-Setting and Stress Peening . . .

. . . Improve Spring Strength

E. H. Spaulding, Lockheed Aircraft Corp.

Based on paper "Lightweight Springs for Limited Life" presented at SAE Golden Anniversary Aeronautic Meeting, Los Angeles, Oct. 13, 1955.

THE working stresses of springs designed for limited life may be increased more than 50% by using pre-set and stress peen techniques. Higher working stresses permit a lighter spring to do a specific job.

A spring in the Constellation (749) main landing gear drag strut damper was redesigned as shown in Fig. 1 to save 17 lb. The spring being smaller, the housing weight was reduced and, with two springs and housings required, a total weight saving of 55 lb per airplane was realized. Since then these springs have served well for over 20,000 service hours. The weight saving was achieved by increasing the working stress more than 50%. Such a high working stress was made possible through the use of pre-set and stress peen techniques applied to springs of unusually high quality.

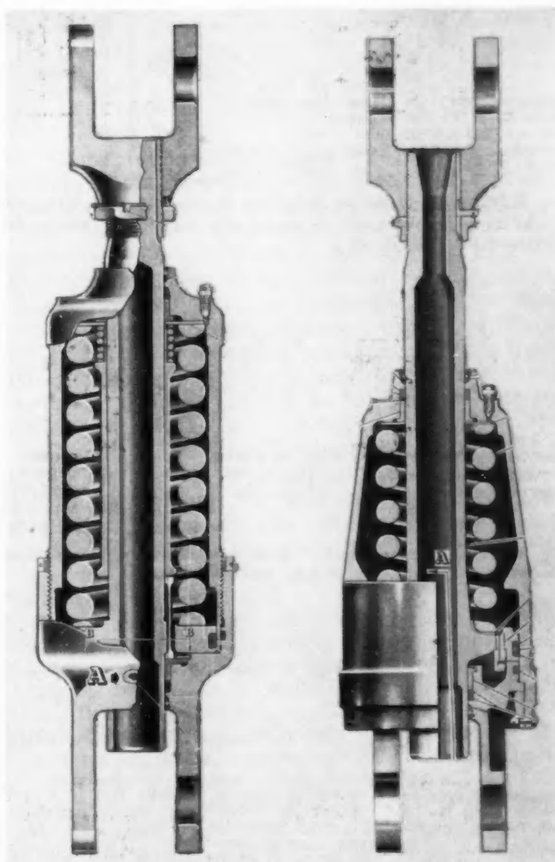

Fig. 1—Constellation (749) main landing gear drag strut damper spring; on the left the old design, on the right the new design featuring a smaller spring and housing. The new design resulted in a weight saving of 55 lb per airplane.

The Pre-Set Operation

The purpose of the pre-set operation is to induce favorable residual stresses that will allow a greater range of working stress without producing permanent set. The spring as wound is longer than desired in its final configuration. It is then deflected to its compressed height, causing a strain approximately double the yield strain and producing a permanent set. After this pre-set operation, the relaxed spring has the desired length called "set height."

Pre-set deflection should be equal to twice the deflection that causes appreciable permanent set. Pre-set greater than this is permissible and will lock in higher beneficial residual stresses, but little is gained and the physical problems of performing the more extensive operations make it impractical.

The spring will buckle and fly from the press if not restrained and guided during the pre-set operation. It is important that the spring be guided by a close fitting tube or mandrel; otherwise it will not

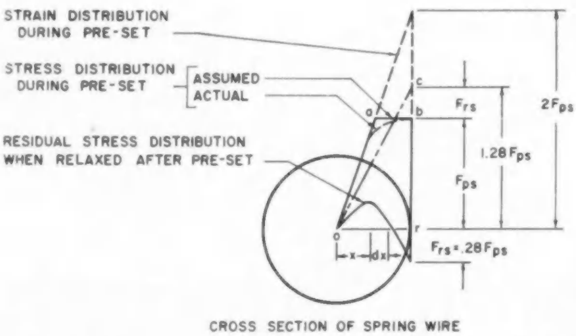

Fig. 2—The average stress distribution within a spring wire during and after pre-set neglecting the Wahl factor.

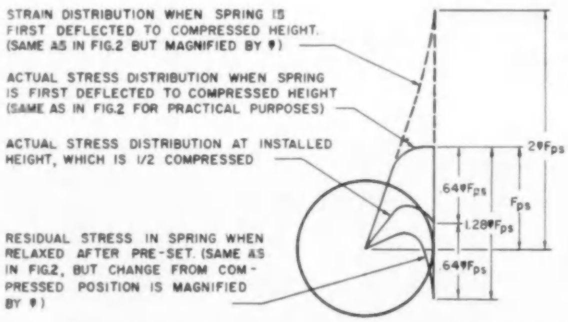

Fig. 3—The cross-section of a spring wire showing the stress distribution at the inner face of the coils during and after pre-set and including the effects of the Wahl factor.

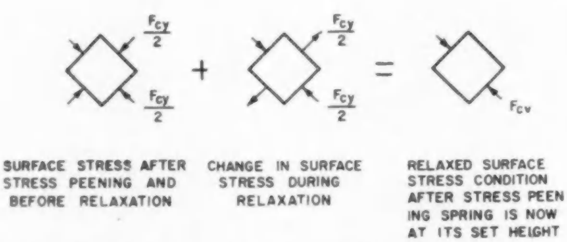

Fig. 4—The spring inner surface stress condition after stress peening, the relaxation process, and the final condition at the set height.

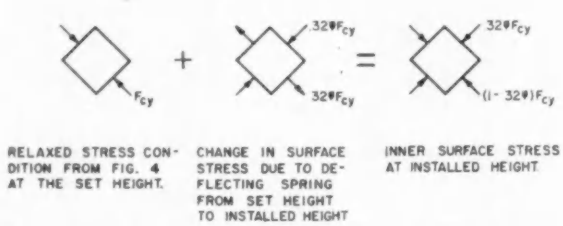

Fig. 5—The spring inner surface stress condition at the installed height.

set evenly and will not be straight. Short of breaking the spring, it is not possible to pre-set too much.

Referring to Fig. 2 and using the assumed stress distribution consisting of two straight lines *oa-ab*, the internal moment within the torsion bar under pre-set load is:

$$T_q = \int_{\frac{r}{2}}^{r} 2\pi X^2 F_{ps} dx + \int_{0}^{\frac{r}{2}} 2\pi X^3 \frac{F_{ps}}{r/2} dx$$

$$T_q = \frac{7}{12} \pi r^3 F_{ps} + \frac{1}{16} \pi r^3 F_{ps}$$

$$T_q = 0.64 \pi r^3 F_{ps}$$

Removal of the pre-set load reduces the internal moment to zero. However, since the recovery is elastic, the condition is equivalent to applying an equal and opposite moment producing a linear stress distribution, shown in Fig. 2 by the straight line *oc*. The ordinate *cr*, representing the change in surface stress due to removal of pre-set load can be found by equating the internal moments produced by the two stress distributions. So:

$$0.64 \pi r^3 F_{ps} = \tfrac{1}{2} (F_{ps} + F_{rs}) \pi r^3$$

and

$$F_{rs} = 0.28 F_{ps}$$

Algebraic addition of stress distributions *oa-ab* and *oc* gives the residual stress distribution shown in Fig. 2 with $0.28F_{ps}$ being the surface residual stress.

When the spring is compressed again it can now move a distance to cause an average stress change on the surface equal to $1.28F_{ps}$ without yielding surface material. This is the gain from the pre-set operation.

Effect of Wahl Factor

Stress distribution within the wire cross section shown in Fig. 2 is only an average condition. Since the wire is wound into a coil, it tends to concentrate more stress on wire surface nearest the axis of the coil. The factor by which this stress is increased is known as the Wahl factor, Ψ, and is sort of a stress concentration factor. Fig. 3 shows the stress condition on the most highly stressed portion of the wire during and after pre-set.

Stress Peening

Shot peening leaves a spring surface in a state of bi-axial compression equal to about one-half the

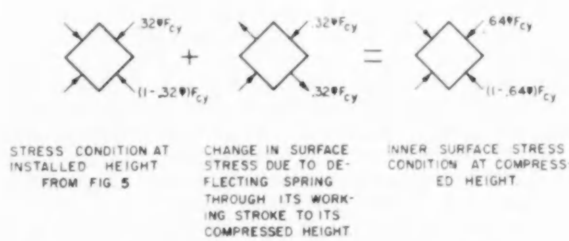

Fig. 6—The spring inner surface stress condition at the compressed height.

yield strength of the material. This affects the surface material to a depth of 0.001 to 0.002 in.

If the spring is compressed somewhat beyond the shear yield stress (F_{ps}) on the most highly stressed inner face and is then shot peened while held in that position, the surface stress condition is changed to bi-axial compression equal to one-half the compression yield stress as shown in Fig. 4. Since the yield stress in shear is usually greater than one-half the tension (or compression) yield stress, it will be conservatively assumed that $F_{ps} = F_{cy}/2$.

When the spring is removed from the jig and relaxed the surface stress changes by F_{ps}, which is assumed equal to $F_{cy}/2$. The final stress in the relaxed state is compression equal to F_{cy} as shown in Fig. 4.

When the spring is compressed to its installed height the surface stress changes by $0.64\psi F_{ps}$, which is equal to $0.32\psi F_{cy}$. This is the beginning of the working stroke. The resulting stresses at the installed height become the values shown by Fig. 5.

When the spring is compressed through its working stroke to its compressed height the change in surface stress is again $0.32\psi F_{cy}$. This operation is shown in Fig. 6.

Under the above conditions the surface of the spring will never be in tension unless the Wahl factor exceeds 1.56, which is improbable because a good spring design will maintain dimensions to keep the factor much lower. This is a desirable condition for fatigue because a failure can't start from the surface under compression. Evidence seems to indicate that the fatigue strength of sub-surface material is higher than for surface material.

During relaxation after stress peening the spring will not quite return to its original set height because of the change in the surface stress condition during the peening operation. About 2 to 5% of the stress peen stroke will be lost. Allowance for this must be provided for in the design if the spring load at its installed height is a critical value.

For complete paper (in multilith form) on which this abridgment is based, write SAE Special Publications. Price: 35¢ to members, 60¢ to nonmembers.

Future of Air Transport . . .

. . . hinges on joint planning by aircraft producers, aircraft operators, and airport operators. Airport facilities are a major consideration.

Based on paper by **Fred M. Glass,** The Port of New York Authority

EVERY dollar spent for such aircraft as the new Electras, DC-7's, Viscounts, and Convairs requires a similar expenditure for new airports and terminal facilities. Consequently, airport operators must know what types of aircraft are being planned; design criteria must reflect the economic, operational, and public relations considerations which have been found to be important and governing factors in major metropolitan airports; and manufacturers must realize the economic and physical limits beyond which it is impossible to go with airport facilities for the aircraft designed.

There is talk of needing 10,000 and even 14,000-ft runways. This is unrealistic. The CAA's provision TSO N-6a, making 8400 ft standard at inter-continental express airports, is now a "must." Future transports needing runways longer than 8400 ft may find their utility limited to shuttling between Muroc Dry Lake and similar military fields.

Runway strength is another item to consider. Critical factors are gross weight and tire pressure. Pavement requirements and costs increase severely when tire pressures go substantially above the present 125 psi. Unless held down, the airports will be faced with a problem of the greatest magnitude.

Noise is also a problem that must be solved. Since service demands that transport terminals be near densely populated areas, noise levels must be acceptable if an adequate volume of traffic is to be permitted.

The four Port Authority airports handle about 2000 landings and take-offs on an average day. On peak days, La Guardia handles about 1000 movements and the other three airports about 1800. That's with fair weather. Under Instrument Flight Rules operations we get into a real problem of congestion. Looking ahead to the time of even greater traffic volume, we are working with the CAA on plans to make instrument runways at the three major New York airports bi-directional. This will help to reduce circular approaches and increase the acceptance rate when the weather is IFR but winds are from the southwest. Progress in air traffic control will have to keep pace with that. At the International airport a second instrument runway is planned, running parallel to the present one but 3000 ft east of it. This will double the IFR acceptance rate. And, again, traffic control will have to keep pace.

With the coming of helicopters, a second air traffic control system will have to be developed to operate separately from, but coordinated with, the present one within the available air space. This can be done successfully.

With high traffic volume must go pilot efficiency and discipline and adequate airborne equipment. At La Guardia, in particular, aircraft should be equipped with at least the VHF frequencies needed to contact in proper sequence approach control, the tower, and then ground control. If only one frequency is available, movements will be slowed to accommodate the poorly equipped aircraft and the entire airport operation will be penalized. (Paper "Air Transportation and the Terminal Area" was presented at SAE Golden Anniversary Aeronautic Meeting, Los Angeles, Oct. 13, 1955. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Making Aeronautical

SAE has been an integral part of aeronautical standardization ever since the start of aero standards in 1917, when SAE published a "Shaft End for Aeronautic Propeller Hubs."

In the less than 40 years since, a philosophy and a set of guiding principles have emerged to delineate the inter-relationships of industry, the military services, and standards-making organizations such as SAE. Experience has showed how each of the three groups can best contribute to cooperative aeronautical standardization.

The present state of the art is an outgrowth of a number of important agreements and decisions reached in achieving this inter-group unity. The following are among the more important of these milestones.

1. The incorporation of numerous commercial standards in the original Army-Navy Standards Series, Part Nos. AN1 to AN1000. This series began in 1926. Coordination with industry was greatly increased by formation of the Working Committee of the Aeronautical Board in 1937.
2. The organization of the NASC, National Aircraft Standards Committee, in 1939. This was a group of about 25 standards engineers of the aircraft manufacturers, which is still very active under the Aircraft Industries Association.
3. The initial publication of AMS, Aeronautical Material Specifications, by the Society of Automotive Engineers in 1940.
4. The agreement reached in February 1941 with the Government's Office of Production Management that aeronautical standardization responsibilities should be assigned as follows:
    - The Aeronautical Board to be the responsible agent for the Army Air Force, Navy Bureau of Aeronautics, and Government activities in this field.
    - The NASC to be responsible for standards governing airframe structure, and installations of engines and accessories.
    - The SAE to be responsible for standards for engines, propellers, parts, accessories, equipment, and for all aeronautical materials standards.
5. The reorganization of the Aeronautics Division of the SAE Standards Committee in 1941. This activity then involved 185 industry and 4 government technical personnel. (I will mention its current size later.)
6. The first issuance, in 1943, of Army-Navy Aeronautical Bulletin No. 143, officially recognizing NAS and SAE standards for use on military equipment.
7. The Philadelphia Conference in 1946 between Air Force, Navy, and the airframe manufacturing industry, to promote more effective use of standard parts.
8. Unsuccessful negotiations throughout 1944-5-6 between the engine industry and the Aeronautical Board regarding standardization policies, culminated in the famous Dayton meeting of October 1947. At this meeting the Engine Technical Committee of the Aircraft Industries Association was able to demonstrate the general inadequacy of AN standard parts for aircraft engine duty, and reached an agreement to undertake the cooperative development of engine and propeller utility parts standards under a new plan.
9. The execution in December 1947 of a formal agreement between Air Force, Navy, and industry to promote the continued use of AMS materials and process specifications for engines and propellers, and to cooperatively support the development of engine and propeller utility parts standards by an appropriate industry committee. It was agreed the accepted stand-

C. E. Mines, Chairman, SAE Aeronautics Committee

Excerpts from talk "Cooperative Aeronautical Standards" presented at ASA Sixth National Conference on Standards, Washington, D. C., Oct. 25, 1955.

Standardization Tick

SAE Aero Standards Groups Play Big Role In Achieving Military-Industry Teamwork

ards would be given AN-Aeronautical numbering. Refinements in the plan were incorporated in a revised agreement signed March 31, 1949.

10. The attainment of a similar agreement with the aircraft industry was marked by the formal execution in August 1948 of a document with a rather long title, "Air Force—Navy—Aircraft Manufacturing Industry Agreement on Standardization Program on Utility Parts and Complementary Materials and Processes for the Aircraft Manufacturing Industry."

11. The release on Oct. 1, 1948 of the first 43 cooperative standards produced in SAE Committee E-25 known as the Engine and Propeller Standard Utility Parts Committee. These covered about 1800 part numbers in the AN-100,000 series, which led to the colloquial designation, "six-digit standards." The numbering has subsequently been adapted to the MS system by using the MS-9000 series sheet numbers with two-digit dash numbers to retain the "six-digit" concept of identification for aircraft engine and propeller utility parts.

12. The formation of CMAS, the Council for Military Aircraft Standards, under a charter dated March 1, 1952, that gave permanent standing to an advisory committee comprising six industry members and eight military members, which is concerned with the military standards used by the airplane manufacturers. The establishment of a second advisory committee to be known as the Council for Military Aircraft Propulsion Standards, or CMAPS, has also been considered by the engine and propeller industries and the military services.

13. The latest milestone I will mention is the issuance in October 1954 of the Department of Defense Directive 4120.3 covering the Defense Standardization Program. This document establishes more clearly than the government has ever said before, that military standardization activity must be coordinated in an effective manner with industry, including trade associations, technical societies, and other standardization organizations. I quote one sentence, "This policy will permit the maximum conservation of engineering effort within the Department of Defense and, at the same time, assure that the requirements of the Department of Defense are successfully geared to existing industrial practices and resources."

Now let us turn to the principles being followed in this work, which make it possible to have effective cooperation in aeronautical standardization.

Principle 1: Industry-Government Responsibilities Spelled Out

The first and most significant principle is that of recognizing the distinct responsibilities of both the government and the industry members of the team. This philosophy was most clearly expressed in the minutes of the Dayton conference of 1947:

"The Services' primary assignments are those of *selection* and *operation*. Industry's assignments are primarily those of *development* and *manufacture*. Inherent in its assignment, the military must establish and prescribe the performance and operational requirements for its equipment. Industry, to the best of its ability, must meet these requirements, but in doing so it must of necessity have freedom of action. It must be

guided by experienced people who know their business and it must use its own judgment in the design and fabrication of its products. Although the joint effort of the services and the industry is recognized as basic to a sound standardization program, ultimate acceptance of the standards for use in military equipment must be exercised when and where necessary by the services as an inherent part of their military responsibilities."

The two parts of this principle are carried into the formal agreements made concerning this work:

"The contribution of the technical know-how of industry is recognized as an essential element in the development of technically sound standards."

and the corollary:

"Final decision as to the adoption of standards shall be made by the Services."

The military responsibility to establish the performance and operational requirements is accomplished by placing the appropriate provisions in the equipment procurement specifications.

Principle 2: Let Manufacturer Use His Judgment

A second major principle is that if the manufacturer is expected to be responsible for his product's meeting the performance and operational requirements, then he must be free to choose on the basis of his best judgment, which standards he will use in his product. In the case of aircraft engines, this is embodied in the general specification by the words, "standard parts shall be used, unless they are determined by the contractor to be unsuitable for the purpose." Thus one might say the usage is voluntary according to the engine's needs.

Principle 3: Quality to Suit Service Need

A third principle for effective standardization is that the quality designed into the standard must be adequate for the product on which it is to be used. A conscientious product designer will not select a standard of inadequate quality, but will always resort to a special design.

The satisfactory performance of aircraft engines and propellers is vital to safety of flight and the accomplishment of military missions. The failure of the tiniest part, whether it be of special design for the particular engine, or a so-called "standard utility part" such as a fastening device, can cause engine failure as completely as the failure of a part such as a connecting rod or turbine wheel.

The selection of items from available assortments of "standard parts" must be made by the engine designer solely on the basis of the ability of the part to perform satisfactorily throughout the very severe service imposed by the qualification test specified for the engine, and to perform with equal satisfaction throughout the expected service life in the field. Experience has proved that there are few, if any, applications for devices in the "standard parts" class which impose more severe duty than occurs in aircraft engines and propellers. The design and selection of such parts must accordingly be done with the utmost care.

Principle 4: Standards Dynamic, not Static

A fourth principle is that standards must not be stagnant. They must grow and advance to keep pace with the new developments in the forward and upward march of aeronautical science. A standard provides economy because it is a solution of a recurring difficulty. But each new difficulty is not always exactly like the last.

There are still some engineers, relatively few in number, who express fear of standardization because they feel that a standard once established is a fixed, dead thing, suppressing improvement and individual initiative. But standardization does not hinder progress, because there is always the possibility of a new and better standard to meet the new and more difficult problems.

An example of how this situation can be met is seen in the procedure for AMS specifications. Each new specification originates with a request by a minimum of two users. Although the procedure for developing and approving the AMS is such as to make it unlikely that any unnecessary ones will be issued, it does permit the preliminary standardization of experimental materials. The procedure also provides that changes can be recommended by any materials user or producer, and will be fully considered for incorporation. As the state of the materials art advances, a specification may be revised many times so that an up-to-date and useful standard will always be available.

Now that we have touched on procedures, I would like to go a little further. This work of cooperative

standardization is done with three M's—Men, Meetings, and Mail. I might add that there is nothing magic about it; it cannot be done with mirrors! Purely and simply it is an organized arrangement for pooling the experience of equipment designers and source manufacturers with that of the military users, and in many cases the airline users, to establish adequate designs for repetitive use.

Facts and Figures about SAE Aero Standards

In the aeronautical standards work of the Society of Automotive Engineers, our three M's involve some astonishing numbers. Under the Aeronautics Committee there are currently five divisions comprising 99 division members. These five are:

1. Aircraft Engine Division
2. Aircraft Accessories and Equipment Division
3. Aircraft Propeller Division
4. Aeronautical Material Specifications Division
5. Special Aircraft Projects Division

Under these divisions there are 51 committees and subcommittees, having 649 members plus seven temporary panels with 98 members. Breaking the total of 846 men down as to their experience connection, we have 776 technicians from industry and 70 members or liaison representatives from government. The latter are distributed 28 from Air Force, 26 from Navy, principally Bureau of Aeronautics, three from Aeronautical Standards Group, two from Army, eight from Civil Aeronautics Administration or Civil Aeronautics Board, two from National Advisory Committee for Aeronautics and one from Bureau of Standards.

The contributions of these government personnel have been outstandingly helpful in this work. It is hoped that a recent Department of Defense Directive, which establishes more liberal policies respecting the participation of military representatives in the technical and standards activities of professional societies and technical organizations, will lead to even more effective cooperative endeavor.

These various committees are likely to meet from once to six times a year. Last year they had a total of 199 meeting days, and the total number of participants exceeded 3000. The tremendous interest and value these meetings have is most apparent in such groups as the AMS Division where the week-long, semi-annual meeting will deal with nearly 200 new or changing specifications and over 50 non-members will attend. Or, take the Hydraulic and Pneumatic Equipment Committee, at whose semi-annual three-day meeting last April only one committee member was absent, and the non-member attendance of manufacturers', users', and Government representatives totaled 301.

It is hard to summarize briefly the results of this great effort. Committee E-25 has 90 active projects on utility parts. Last year it completed 29 and recommended them to the Services for issue. A survey of the engine and propeller manufacturers early in 1955 showed that these six-digit standards were being specified for 23,742 applications.

The several SAE committees submitted detailed recommendations on a total of 165 government specifications and drawings. SAE Aeronautical Standards were issued on Surface Finish, and on Flight Directors and Electric Tachometers (for the CAA). Several important Aeronautical Recommended Practices were issued.

Also last year, 38 new and 71 revised AMS were issued. Now 676 active specifications comprise a complete set of AMS and a total of nearly ten million copies have been sold to date. This program on Aeronautical Material Specifications has now existed for more than 15 years. It represents the greatest achievement to date in cooperative standardization between industry and government and has been the stimulus and pattern for much other work.

In closing, let me mention some problems and some pitfalls. They are all related to safety of flight. If a standard part fails in an automobile or train, the vehicle can usually be stopped without casualty. If it happens in an airplane or a submarine, one doesn't step out on *terra firma* and make a repair.

First Problem: Our systems do not yet give adequate protection against the substitution of unproven parts for those so carefully selected and tested by the product designer. Distinctive part numbering and distinctive marking of aeronautical standard items are musts. Unfailing identification in supply systems must be a reality rather than a myth.

Second Problem: The product designer's know-how should be recognized as vital on changed parts, just as it is now recognized on brand-new parts. Someone appears to believe it is illegal for the government to agree to this principle.

Third Problem: A clear understanding is needed that it is legal to include in a series of standards a recognition and definition of a proprietary device which has been proved trustworthy.

One Pitfall: If it is attempted to encompass too many fields of use when establishing a standard, the resulting design may be really inadequate for a critical use as in the air. It is also possible that the adoption of a single, broad usage standard may result in inadequate producibility.

Small changes in design will cause large changes in . . .

High-Speed Tire Performance

T. J. P. Joy,
D. C. Hartley,
and D. M. Turner,
The Avon India Rubber Co., Ltd.

Based on paper "Tires for High Performance Cars" presented at SAE Golden Anniversary Summer Meeting, Atlantic City, June 15, 1955.

In the original paper on which this abridgment is based the authors also describe various laboratory equipment used in obtaining new experimental data. They discuss power-consumption of high-speed tires, and variations in tire characteristics due to extreme braking and traction forces.

They also investigate the factors affecting the handling of a high-speed car during cornering and at the point of tire breakaway.

The complete paper will appear in 1956 SAE Transactions and is available in multilith form from Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.

INCREASING high-speed tire performance, and at the same time decreasing tire noise, often presents the designer with a dilema. Changes in design which help the former may create greater problems in the latter field. Here, in easy-to-read chart form, are data for tire designers to help pinpoint their performance-noise problems.

Tires can be designed for good, high-speed performance only by sacrificing other characteristics. If the high-speed characteristics are obtained by using low crown angles, stiff undertread constructions, or high inflation pressures, they are obtained only by sacrificing ride comfort. Even if tire deflections are kept similar to conventional low-pressure tires by using extremely flexible casings, tires will tend to lose directional stability at high speeds due to the reduction in lateral stiffness of the tire casing.

How tire design changes affect performance can be seen in the following chart. When the design factors listed in the first column are increased, cornering force, self-aligning torque, and horsepower consumption are affected as shown.

Generally these performance characteristics hold true under dry road conditions which give a high coefficient of friction. When the road is wet, and the coefficient is reduced, the detail design of the tread pattern becomes more important. Best performance comes from a very intimate contact between the tire and the road. The water film, normally present between tire and road, must be completely broken down. This may be accomplished by designing drainage paths into the tire, such as using a studded pattern or slotting the fundamental ribbed design.

These modifications may cause excessive tire noise, especially when the tires are partly worn. So, the pattern must be designed to scramble the frequency of the notes produced by the tire and reduce their sound level. Changing the hardness of the tread compound, or changing inflation pressure will affect tire noise, too. In the following chart the four main types of tire noise, squeal, hum, squelch, and rumble are described.

Table I—Influence of design factors on performance of high-speed tires

Increase in design factors listed below result in:	Cornering Force	Self Aligning Torque	Horse Power Consumption
Slip angle	Steady increase	Increase up to a maximum at about 6 deg slip, then decrease	Steady increase, slightly greater than expected increase of C.F. sin α
Camber angle	Camber thrust proportional to tangent of camber angle; also proportional to load except at higher loads when increase becomes less. (Camber thrust and cornering force independent of each other)	No effect	Slight increase
Speed	No effect	No effect	Rapid increase
Pressure	Steady increase	Steady decrease	Slight decrease at slip angles less than 5 deg; slight increase above this
Braking	Below 4 deg slip, no effect noticeable; above 4 deg, decrease becomes marked	Decrease of both torque and slip angle at which it reaches a maximum	No effect
Traction	Slight decrease	Increase of both torque and slip angle at which it reaches a maximum	No effect
Rim width	Increase	No effect	No effect
Rim diameter	Increase	Increase	Slight increase resulting from higher cornering force
Section width	Increase	Increase	No effect
Number of plies	No effect	Decrease	No effect

Table II—Cause, effect, and solution of tire noise

Noise	Caused by these road conditions	Medium of transmission	Component of tire generating noise	Features in tire which reduce noise	Influence of tread compound	Influence of inflation pressure
Squeal	Cornering Smooth surface Hot and dry	Airborne	Relaxation type oscillation of tread elements coupled to the casing acting as a resonating chamber	Irregularity in the tread pattern and features to prevent independent vibration of ribs	Harder tread gives a higher frequency and is more irritating	Higher pressure increases frequency but also increases the critical cornering force for squeal
Hum	Straight running Smooth surface	Airborne	Impact of regularly placed features in the tread pattern	A) "Frequency Modulation" of distance between similar pattern elements B) Distribution of pattern elements to eliminate lower frequencies	Softer and lower resilience tread gives a slight improvement	Reducing the pressure in a particular tire increases the noise, as a result of the greater deflection
Squelch	Straight running Smooth surface Hot and dry	Airborne	A squeal type noise due to flattening of a curved tread on impact with the ground	Flatter tread surface	Same as for squeal	High pressure reduces noise by decreasing deflection
Rumble	Straight running Rough surface	Transmitted through the chassis	Vibration of the casing initiated by irregularities in the road surface	Broken up tread patterns have a slight effect	Softer treads better	Lower pressures reduce noise

High-Speed Aircraft Brings . . .

High Temperature

AERODYNAMIC heating of high-speed aircraft presents many structural design problems. Of major importance are:

1. The loss of strength, and creep of structures at uniform elevated temperatures.

2. Thermal stresses, thermal buckling, and reduction of stiffness caused by nonuniform temperature distribution as a result of changing flight conditions.

Mention will be made of design approaches that may alleviate these undesirable effects.

Strength and Creep of Structures

The loss of strength of structural materials at elevated temperatures is the most obvious and probably the most serious of the structural problems encountered by high-speed aircraft. The variation of strength with temperature is shown in Fig. 1.

Stress is plotted against temperature for tensile and compressive loadings of 2024-T3 aluminum alloy that had been exposed to temperature for ½ hr before loading. The dashed curve gives the ultimate tensile strength and the solid lines give the compressive strength of simply supported plates for width-thickness ratios (b/t) of 20, 30, 45, and 60.

For the plates, the maximum average stress the plate will support is given. This maximum stress is approximately equal to the buckling stress for b/t equal to 20 and 30, but it is substantially higher than the buckling stress for b/t equal to 45 and 60.

Fig. 1 shows a significant decrease in strength at temperatures above 400 F. The plate curves show a slight increase in strength at 400 F due to artificial aging of this alloy.

In addition to the loss of strength at elevated temperatures, the time spent under load and temperature also has an effect, as shown in Fig. 2. Stress is plotted against time in hours, with the left-hand curves for tensile loads and the right-hand group for compressive loads.

These particular data are for a temperature of 500 F where the effect of time at temperature is large, but similar effects are observed at other temperatures.

In the tension case, the curves show the ultimate tensile stress and the tensile yield stress as dashed lines and the creep rupture stress as a solid line. There is a significant difference between the load-temperature-time combinations that give the dashed and the solid curves.

To get the dashed lines (static strength test results), the specimen is exposed to temperature alone for the specified number of hours and then is loaded to failure. The solid curves (creep test results) are obtained by applying the load and then exposing the specimen to both load and temperature until failure occurs.

A similar set of curves is shown for compression loads on plates of width-thickness ratios of 20 and 45. Again the dashed curve is the maximum load carried in a static strength test and the solid curve is for creep collapse of the plate.

All curves show a substantial decrease of stress with increasing time. This is expected in creep curves, but the large effect of exposure time on static strength is a characteristic of aluminum alloys that is not so pronounced in most other structural materials.

Comparison of the static strength of the material in tension with the compressive strength of a plate of width-thickness ratio 20 indicates that the maximum strength in tension is higher in this range of exposure times. On the other hand, the creep curves show that this plate is capable of carrying slightly higher stresses in compression than in tension for creep lifetimes up to 100 hr.

The data presented here cover two extreme types of load and temperature histories, that is, in the static strength test the structure is exposed to temperature for a time and then loaded to failure, whereas in the creep test the structure is loaded and then exposed to both load and temperature until failure occurs.

The airplane structure, however, does not experience such simple histories; it experiences a number of heating cycles of variable duration and temperature and during any such cycle experiences a some-

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Based on paper "Some Elevated Temperature Structural Problems of High-Speed Aircraft" presented at SAE Golden Anniversary Aeronautic Meeting, Los Angeles, Oct. 13, 1955. Paper will be published in full in 1956 SAE Transactions.

Structural Problems

. . . which may be alleviated by proper design approach

what random application of load that varies in duration and magnitude. The behavior of materials and structures under such conditions is not yet established, but is being studied.

Effect of Creep on Structures

Data such as those of Fig. 2 show that creep would be the primary consideration when designing an aluminum-alloy structure for a temperature of 500 F. The creep curves lie below the static strength curves, indicating a lower allowable stress and thus more weight.

This is not necessarily true for an airplane structure, however, since as previously mentioned it experiences many temperatures and loads and spends only a small part of its life at the temperature and load combinations that produce significant creep. Therefore, the creep lifetime of an airplane structure at design load and temperature could be substantially less than the exposure time used to establish the static strength.

Fig. 3 shows a comparison of the weight required to support a given tensile load for several design conditions. The weight required (in arbitrary units) is plotted against temperature. The solid curves give the weight required when creep rupture is used as the design criterion for lifetimes of 10, 100, and 1000 hr, respectively.

The two dashed curves give the weight required for static strength after 1000-hr exposure; the upper curve (dash-dot) is for yield strength, and the lower curve (dash-dash) is for ultimate strength. Since the creep rupture curves fall both above and below the strength curves, the weight required will be determined by the particular combination of loads and times used.

The total time that a high-speed airplane will

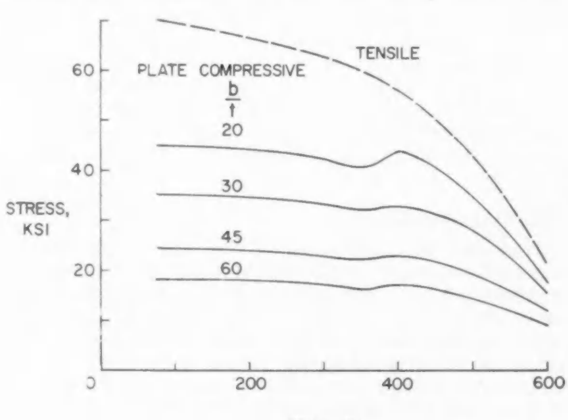


Fig. 1—The variation of strength with temperature for tensile and compressive loadings of 2024-T3 aluminum alloy. The compressive curves are for simply supported plates with various width-thickness ratios (b/t).

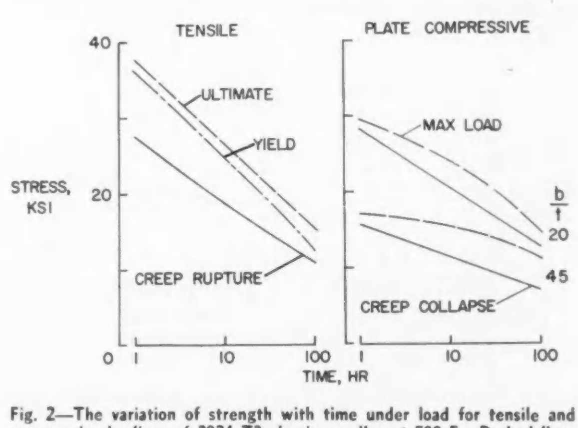


Fig. 2—The variation of strength with time under load for tensile and compressive loadings of 2024-T3 aluminum alloy at 500 F. Dashed lines indicate that the specimen is exposed to temperature alone for the specified number of hours and then loaded to failure. The solid lines are obtained by applying the load and then exposing the specimen to both load and temperature until failure occurs.

spend at supersonic speed and thus at elevated temperatures might be estimated as 1000 hr. The airplane will probably spend less than 10% of this time at load levels high enough to produce creep of the structure.

A resonable design approach, then, is to require the structure to have sufficient strength to support the design limit load without yielding after 1000 hr of exposure to temperature or to have the ability to support the design limit load at temperature for 100 hr without rupturing, whichever requires the greater weight.

This approach indicates that the static strength governs the design up to about 325 F, and that above this temperature the two criteria require almost equal weights. Such considerations indicate that creep may have little effect on the design of aluminum-alloy-aircraft structures. The situation is somewhat different for other materials, however.

Fig. 4 is a similar comparison for three structural materials. Weight (in arbitrary units) is plotted against temperature for 2024-T3 aluminum alloy,

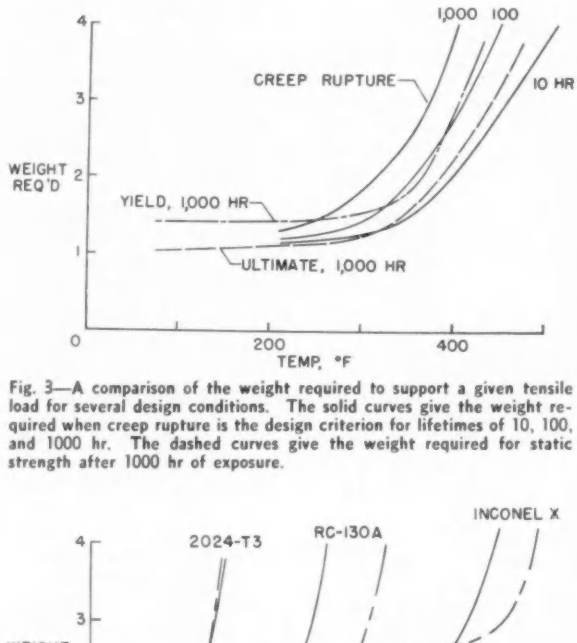


Fig. 3—A comparison of the weight required to support a given tensile load for several design conditions. The solid curves give the weight required when creep rupture is the design criterion for lifetimes of 10, 100, and 1000 hr. The dashed curves give the weight required for static strength after 1000 hr of exposure.

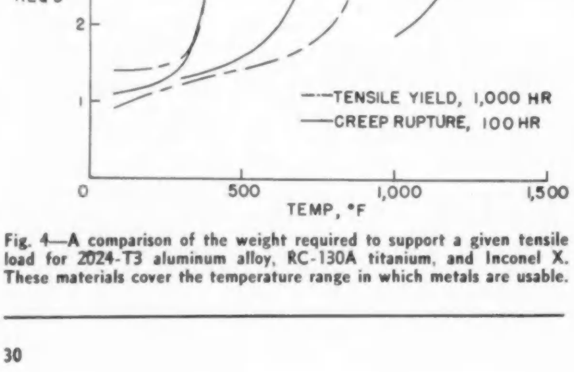


Fig. 4—A comparison of the weight required to support a given tensile load for 2024-T3 aluminum alloy, RC-130A titanium, and Inconel X. These materials cover the temperature range in which metals are usable.

RC-130A titanium and Inconel X, materials which cover the temperature range in which metals are usable.

The weight required to support the load on the basis of yield strength after 1000 hr at temperature is given by the dash-dot lines. The weight required to meet the creep criterion, rupture after 100 hr at load and temperature, is given by the solid lines. At each temperature the higher line for a given material determines which is the governing design criterion.

For the aluminum alloy, the creep criterion requires less weight than the strength criterion so that creep is no problem under these conditions. Creep is no problem for Inconel X up to 1200 F, but above this temperature creep would govern the design. For the titanium alloy, the creep criterion governs the design throughout the temperature range.

So, it thus appears that creep may or may not have a significant effect on the design of structures for high-speed airplanes, depending on both the materials involved and the design criteria used. In cases where creep may influence the design, conversion to another material or alloy may remove creep from consideration and increase the structural efficiency of the design.

Another factor which requires some consideration is the effect of prior creep strain on ultimate strength. Exploratory tests on aluminum-alloy plates indicate that creep strains approaching those expected at collapse cause at most a slight reduction in the maximum strength below that expected from a static test following an equally long exposure to temperature.

It is too early to state how these factors will combine to determine the true influence of creep on the design of structures for high-speed airplanes. It appears that creep may well be a major design criterion only at the high temperatures where all available materials experience significant creep.

For the time being, a conservative design approach combined with proper selection of materials will avoid creep problems. However, the static strength of light alloys cannot be utilized to the fullest in high-speed airplanes nor can the maximum usable temperatures be determined for other metals until a realistic creep design criterion is established for aircraft structures.

A realistic creep criterion must take full cognizance of the particular types of load and temperature histories experienced by high-speed airplanes or needless weight may be added to the structure.

Thermal Stresses

Thermal Stresses arise from the restraint of thermal expansion and may occur when a structure is subjected to a nonuniform temperature distribution. In general, the hot parts try to expand and develop compressive stresses while the cool parts develop the combination of tensile and compressive stresses necessary to make the thermal stress distribution a self-equilibrating system.

Fig. 5 shows the thermal stress distribution in a structural element following acceleration to supersonic speed. Stress is plotted against distance measured along the upper skin to the web, down through the web to the lower skin, and then along

the lower skin as indicated by the dimensions A, B, and C.

The solid curve gives the thermal stress distribution and the dashed curves give the load stresses due to an applied bending moment. The overlapping portions of each curve give the stresses in the skin and web flange where the two are in contact. The difference in the thermal stresses at the joint is due to the temperature drop across the connection.

As is usual in wing structures, the load stresses are compressive in the upper skin and tensile in the lower skin. The thermal stresses consist of compression in the hot skins and tension in the web. The compressive stresses in the skin are the maximum resulting from the acceleration to supersonic speed.

It is evident in this case that the thermal stresses increase the compression in the upper surface and decrease the tension in the lower surface. They also add large tensile stresses to the web which may influence the design of this member.

The above results are for the maximum thermal stresses resulting from the acceleration to supersonic speed. The situation is somewhat different during deceleration as shown in Fig. 6. The presentation is similar to Fig. 5 but here the thermal stresses are smaller in magnitude and reversed in direction, that is, there is tension in the skin and compression in the web.

The tensile stresses in the skin are the maximum resulting from the deceleration. Thus for this phase of the flight the compression in the upper surface is relieved and the tension in the lower surface increased. In addition, there is compression in the web.

The fact that the thermal stresses increase the stresses in some part of the structure each time the flight condition is changed could be a serious design problem. The appearance of compression in the web during deceleration and the increased compression in the skin during acceleration may be of particular significance because these stresses may cause buckling.

Such problems would be eliminated if the structure could be designed free of thermal stresses. Several approaches can be used to reduce the magnitude and alter the distribution of thermal stress, for example, altering the area ratio of skin and web, reducing the coefficients of thermal expansion, using different materials for skin and web, or by lowering the extensional stiffness of the web.

Each of these approaches can result in a reduction of the restraint between skin and web and thus lower the skin stresses. Of these approaches, changing the stiffness of the web seems to offer the best remedy for general use.

The thermal stresses can be substantially reduced if the web is designed to expand and contract freely with the skin while continuing to perform its functions of stabilizing the skin and carrying shear. Webs with closely spaced vertical corrugations or pin-jointed trusses are types of construction that meet these requirements.

Thermal Buckling of Multiweb Beams

It may not be necessary or feasible in many cases to use construction that reduces thermal stresses to a negligible level. The structure may then be designed to withstand thermal buckling and hence it is appropriate to examine some of the factors that influence the thermal buckling of mulitweb structures. Obviously, buckling should be prevented to avoid deformation of the aerodyynamic surfaces and the lower structural stiffness of a buckled structure.

In order to study the thermal buckling of structures, the web spacings required to prevent buckling of a multiweb beam were calculated for various load stresses in combination with the maximum thermal stresses produced by an instantaneous acceleration from rest to a given Mach number.

In this analysis, the temperature distribution was calculated by an approximate method and these temperature distributions were then used to determine the maximum thermal stresses in the skin. The web spacing was found by equating the thermal stresses in the skin to the elastic buckling stress of a simply supported plate.

Throughout the analysis, it was assumed that all

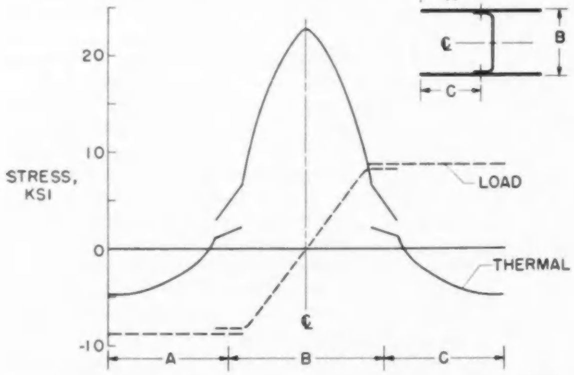


Fig. 5—Thermal stress distribution in a structural element following acceleration to supersonic speed. The solid curve gives the thermal stress distribution and the dashed curve gives the load stresses due to an applied bending moment.

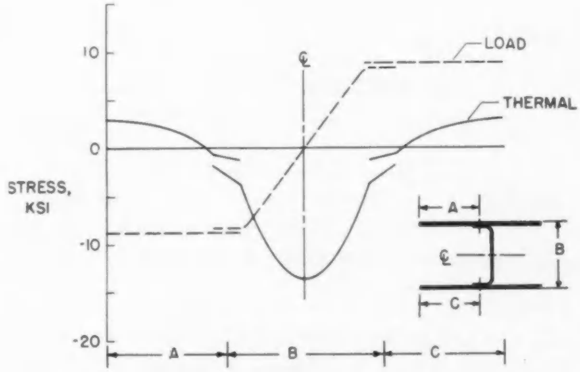


Fig. 6—Thermal stress distribution in a structural element during deceleration from supersonic speed. The thermal stresses are smaller than those of Fig. 5.

stresses were elastic and that material properties did not vary with temperature. These two assumptions give rise to errors in the analysis but they do not invalidate the trends indicated. Variation of some material properties with temperature could have been included but the analysis would have been much more complex.

Plasticity effects were excluded because effects of plasticity on thermal stresses have not been established. Thermal buckling in the elastic range is well defined but has not been investigated when the thermal stresses are in the plastic range.

Similar considerations apply to the interaction of load and thermal stresses. Since all these factors could not be included, the analysis was restricted to the simplest approach that would yield trends.

Fig. 7 shows some combinations of dimensions of a simplified aluminum-alloy multiweb beam that make it susceptible to thermal buckling under symmetrical aerodynamic heating conditions. The required spacing of the webs (on a logarithmic scale) is plotted against Mach number for several values of the applied load stress.

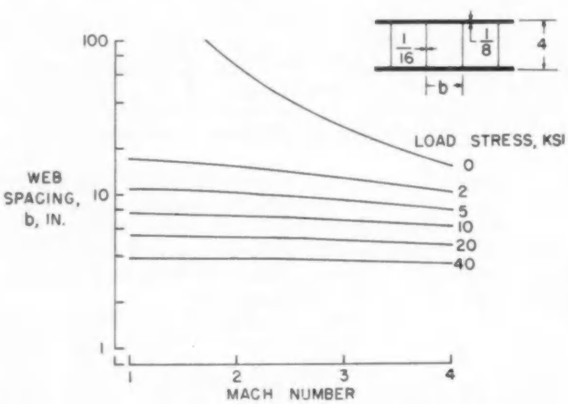


Fig. 7—Dimensions of a simplified aluminum-alloy multiweb beam that make it susceptible to thermal buckling under symmetrical aerodynamic heating conditions. The required spacing of the webs is plotted against Mach number for several values of the applied load stress.

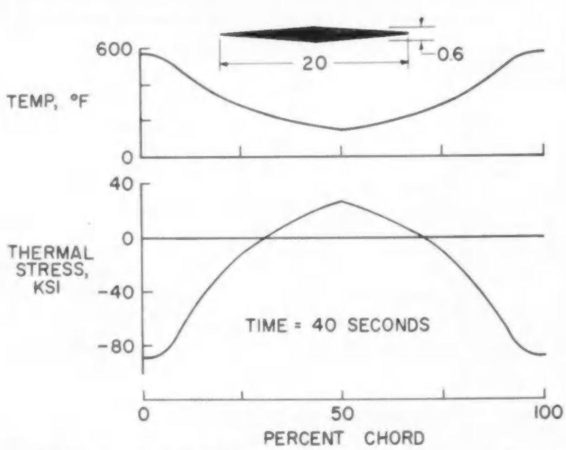


Fig. 8—The temperature and thermal stress distribution in a 3%-thick, solid, stainless-steel, doubled-wedge airfoil section of 20-in. chord. Temperature and stress are plotted against percent chord at a particular time during a flight at a Mach number of 3 at 40,000-ft altitude.

For web spacing above a line, the combination of load and thermal stresses will buckle the skin, whereas below a line buckling will not occur.

When there are no load stresses present, skin buckling can be prevented easily because the thermal stresses produced by these flight conditions are very small. The addition of load stresses requires substantial reductions in the web spacing, but the thermal stresses have a smaller effect on the web spacing as the load stresses are increased.

At a Mach number of one, there are negligible thermal stresses in the structure and the web spacing given is essentially that required to support the load without buckling. At higher Mach numbers, the thermal stresses become significant and at a Mach number of 4 they require reductions in web spacing ranging from 40% for a load stress of 2 ksi to a reduction of only 9% for a load stress of 40 ksi.

So, thermal stresses have only a small effect on the web spacing of an efficient load-carrying multiweb beam, that is, one designed to carry high load stresses. The thermal stresses in the skin are large due to the close web spacing, but they are relatively small compared to the load stress and the buckling stress.

The same general trends are observed for stainless steel, but the required changes in web spacing are larger. With a steel structure one might expect that larger web spacings could be used to prevent thermal buckling because the coefficient of expansion is smaller than that of aluminum alloy.

However, the thermal conductivity is much lower for the steel with the result that larger temperature differences, and thus thermal stresses, are produced by the aerodynamic heating.

Thermal Stresses Lower Stiffness

Thermal stresses well below those required for buckling can very significantly reduce the stiffness of structures. These reductions in stiffness are similar to the reduction of bending stiffness of a beam produced by an axial load, but the reductions in stiffness produced by thermal stresses can take many forms and range from reductions in local panel stiffness to reductions in overall stiffness of a wing or tail surface.

The various types of stiffness changes produced by thermal stresses and the manner in which they influence the design are a new subject of research, but the nature of these effects can be shown by the reduction of torsional stiffness experienced by solid-section airfoils. Solid sections were selected since they are most affected by this phenomenon.

Fig. 8 shows the temperature and thermal stress distributions in a 3%-thick, solid, stainless-steel, doubled-wedge airfoil section of 20-in. chord. Temperature and stress are plotted against percent chord at a particular time during a flight at a Mach number of 3 at 40,000-ft altitude.

It was assumed that the airfoil was instantaneously accelerated to the flight condition and the temperature and stress distributions were calculated by neglecting heat conduction in the airfoil and by using a heat transfer coefficient assumed constant across the chord. The temperature and

thermal stresses thus arise solely because of the chordwise variation of mass in the airfoil.

Note that large compressive stresses are present near the leading and trailing edges and that there are tensile stresses in the midchord region. If the wing is twisted by an applied torque, the compressive stresses will act to increase the twist while the tensile stresses will resist the torque, but the compressive stresses will produce the larger twisting moment.

Consequently, the wing twists more under the action of these thermal stresses than it would due to the applied torque alone. The thermal stresses thus reduce the torsional stiffness of the section.

A history of the effective stiffness of the airfoil is given in Fig. 9 where the ratio of effective torsional stiffness (GJ) to the initial torsional stiffness (GJ_0) is plotted as a function of time in minutes. The stiffness drops very rapidly as the airfoil is heated.

In less than a minute, the section has lost over 80% of its original stiffness. Then as the temperature distribution becomes more uniform, the section gradually returns to its initial stiffness. The temperature and stress distribution shown in Fig. 8 are those that exist at about the time of minimum torsional stiffness.

The loss of torsional stiffness illustrated can be very serious in that it could cause loss of aileron effectiveness or lead to bending-torsion flutter of the wing. It is well to examine the factors that influence the amount of stiffness lost.

For a solid airfoil, the significant factors are the shape, the coefficient of thermal expansion, the thickness ratio of the airfoil, and the maximum possible temperature difference. This temperature difference is a function of Mach number and ambient temperature.

For a given material and shape the thickness ratio that produces a given loss of stiffness can be plotted as a function of Mach number as in Fig. 10. These curves give the maximum loss of torsional stiffness and have been drawn to indicate thickness ratios that may retain only 3/4, 1/2, or none of the initial torsional stiffness.

The condition of zero stiffness is somewhat misleading in that an actual wing would possess some stiffness but would be buckled in a twisted or torsional mode. The zero stiffness is a consequence of the small-deflection theory used to calculate these curves. The net result is that thin airfoils may experience substantial reductions in torsional stiffness at high speeds.

Loss of torsional stiffness can be avoided by any means that reduces the thermal stresses. One factor at the disposal of the designer is the shape of the airfoil section which may be altered to minimize this problem.

Since the curve for zero torsional stiffness in Fig. 10 is a basic one from which the others can be easily derived, it will be used to illustrate the effect of airfoil shape on loss of stiffness. The case of theoretical zero stiffness is also significant because it corresponds to torsion buckling of the airfoil. Fig. 11 is another plot of thickness ratio against Mach number.

Two curves are shown; the upper one is the zero stiffness curve for the double wedge given in Fig. 10, the lower one is a comparable curve for a modified double wedge of uniform thickness for half the

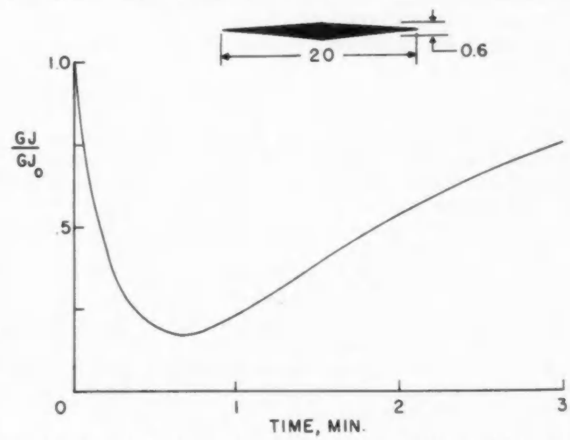


Fig. 9—Shown is a ratio of the effective torsional stiffness (GJ) to the initial torsional stiffness (GJ_0) plotted as a function of time in minutes. Note that the stiffness drops very rapidly as the airfoil is heated.

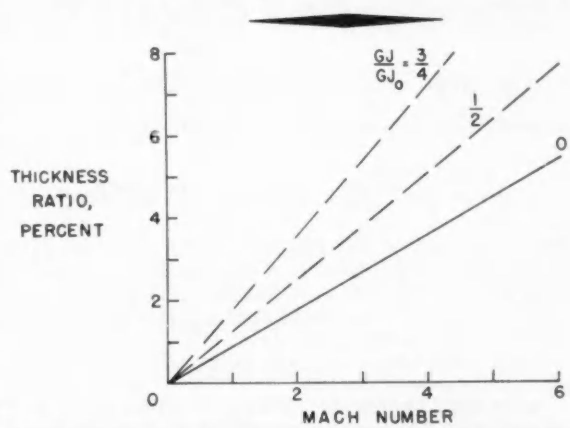


Fig. 10—For a given material and shape the thickness ratio that produces a given loss of stiffness can be plotted as a function of Mach number. These curves give the maximum loss of torsional stiffness and have been drawn to indicate thickness ratios that may retain only 3/4, 1/2, or none of the initial torsional stiffness.

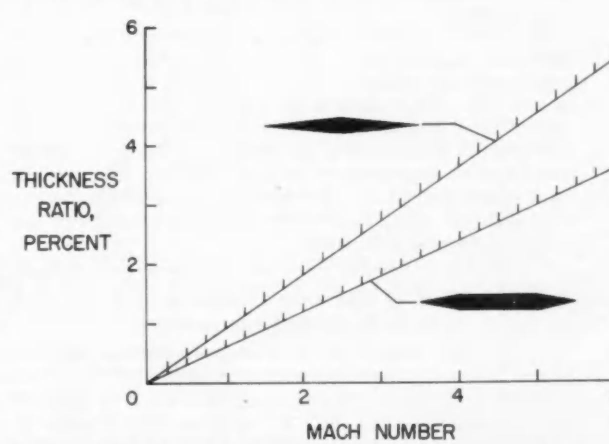


Fig. 11—This is another plot of thickness ratio against Mach number. The upper curve is the zero stiffness curve for a double wedge. The lower one is a comparable curve for a modified double wedge of uniform thickness for half the chord.

chord. For each section, thickness ratios on or below the line may lead to complete loss of stiffness, and thus to torsional buckling, due to thermal stresses.

At any Mach number, the modified section can be used at a lower thickness ratio than the double wedge and still retain the same percentage of its initial torsional stiffness. Hollow sections are even less susceptible to loss of torsional stiffness than solid sections and it is theoretically possible to design a hollow airfoil that will lose a negligible amount of stiffness.

Both Fig. 10 and 11 are limited to a particular range of altitudes so that Mach number can be related to temperature, but altitude has only a small effect on the location of the curves shown. It is significant that the maximum possible percent loss of stiffness is independent of the rate of heat transfer to the wing or absolute size of the wing.

The size and heat transfer coefficient do, however, determine the rate at which stiffness is lost and the time required to reach the point of minimum stiffness. Increasing the size of the airfoil or the flight altitude reduces the rate at which stiffness is lost.

Other factors that influence the amount of stiffness lost are the aspect ratio and the rate of acceleration, both of which were assumed infinite in the preceding examples. Finite values of either aspect ratio or acceleration, however, give a loss of stiffness that is only slightly less than that indicated in Fig. 10 and 11, except when the aspect ratio or acceleration is very small. The principal effect of a finite acceleration is to reduce the rate at which stiffness is lost.

For complete paper (in multilith form) on which this abridgment is based, write SAE Special Publications. Price: 35¢ to members, 60¢ to nonmembers.

Vapor Lock Tolerance . . .

. . . greater in postwar cars. Design improvements boost resistance to volatility, point way to increased use of light ends.

Based on paper by **R. E. Barnum, P. J. Clarke, and J. P. Hamer,** Esso Laboratories, Standard Oil Development Co.

FIELD tests and surveys show that postwar cars are better equipped than prewar cars to handle high volatility gasolines without running into vapor lock troubles. This means that greater use can be made of light hydrocarbon fractions. It's good news to oil refiners because supply of these light ends has always exceeded demand.

A survey was made of 50 cars in New Jersey and 33 cars in southwestern United States to evaluate their vapor locking characteristics. They covered the model years 1946 through 1953. It was found that the limiting vapor lock condition for the group occurs when the cars are accelerated following a soak period.

But it was also found that the difference was small between maximum volatility permissible during acceleration versus that of the next most critical type—idle. This difference is only one pound Reid vapor pressure at the volatility level where all cars are free of vapor lock, as shown in Table 1, where the relative importance of the three types of vapor lock is compared for the 50-car group evaluated in New Jersey. The difference is greater at lower degrees of car satisfaction.

Table 1—Effect of Operating Conditions on Vapor Lock (at 85 F Ambient Temperature)

Condition	Maximum Allowable Rvp[1] @ Car Satisfaction of . . . 95%	100%
Acceleration	10.8	10.3
Idle	13.4	11.3
Start	14.9	12.9

[1] Percent evaporated at 158 F is 25.0

The results of the New Jersey survey were substantiated by the survey in southwestern U. S.

To compare postwar and prewar cars, reference was made to a statistical study of vapor locking characteristics made by Esso Laboratories in 1941. Comparing results of the prewar and postwar studies showed that:

1. Big improvements have been made over the years in the ability of cars to use higher volatility fuels.
2. Prewar cars were limited to idle-type vapor lock in contrast to the acceleration vapor lock of postwar cars.

It's obvious that the car makers have designed their vehicles to resist vapor lock. The beneficial changes include use of new carburetor designs, moving fuel pumps away from engine hot spots, and rerouting fuel lines. A case in point is a popular six cylinder car which was built with a new carburetor in 1949. The tolerance of the 1949 and later models of this car make is some 2 Rvp units greater than the 1946–48 models with the old carburetor.

The vapor lock studies show that postwar cars can handle more volatile gasolines than the average of those currently marketed. On the average, an increase of about one pound Rvp is possible at 85 F without causing vapor lock troubles. If acceleration vapor lock could be eased, more of the benefits inherent in higher volatility fuels could be realized.

(Paper "Vapor Locking Characteristics of Passenger Cars" was presented at SAE Summer Meeting, Atlantic City, June 11, 1954. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

6 Ways To Prevent Indigestion In Residual-Burning Diesels

Gregory Flynn, Jr., Research Laboratories Division, GMC

Based on secretary's report of round table discussion on "How to Burn Heavy Diesel Fuels" held at the SAE Summer Meeting, Atlantic City, June 14, 1955.

RESIDUAL fuels, because they are cheap, are being studied with great interest by railroad operators of diesels. They have seen with what success they have been used in marine and industrial diesels. Now they feel the time has come to apply them to locomotive diesels. They are finding, however, that it is not simply a matter of loading the tanks with residual fuel instead of distillate.

The heavy fuel has certain characteristics that must be taken into account. In particular, it has higher viscosity and generally contains more contaminants than more expensive fuels.

This has made it necessary to devise ways of helping the engine digest its diet of residual fuel better. Some of these ways are:

1. Using a blend of residual and distillate.

2. Using purifiers and filters to remove water and other contaminants.

3. Heating the fuel before it goes to the injector.

4. Using distillate fuel for starting and idling, changing over to residual for cruising.

5. Using better crankcase oil, and draining it more frequently.

6. Raising the jacket water temperature.

Blended Fuel

Large, slow-speed marine engines are able to burn 100% residual fuel because:

1. There is sufficient time and space to ensure complete combustion.

2. Operation is at practically constant full load for most of the time.

These favorable factors are not present for the locomotive diesel. First, the engines are smaller and they operate at higher speeds. Second, a railroad diesel is operated 30–50% of the time at practically idle load, with the remainder at 60–100% full load.

For these reasons, it is necessary to blend the residual fuel with a high per cent of distillate before it can be used in today's locomotive diesel.

Experiments are now going on with blends of 2D diesel fuel (a distillate fuel oil of low viscosity) and No. 5 fuel oil (a residual oil). Actually, a good many railroads are now using a downgraded No. 2D fuel. This fuel is not too different from the regular diesel fuel and, in most cases, is made up of distilled and cracked fuels. For the larger users, such as the major railroads, a small saving in cost per gallon represents a substantial dollar saving in the annual fuel bill. One railroad is reported to have saved over one-half million dollars in one year by using a downgraded 2D fuel costing but 1¢ per gal less than regular diesel fuel.

There are many considerations involved in selecting a downgraded diesel fuel for mobile equipment. It is not always simply a case of buying cheaper and lower-grade fuels and enjoying the savings.

To enjoy the savings of the lower-grade fuels, however, it is important that the user be willing to accept the fuel or mixture of fuels as it is available in his area. He cannot expect to issue closely written specifications for these cheaper fuels. If the fuel

has undesirable qualities, he must compensate for them by means of equipment designed to modify them.

One precaution must be taken, though: There must be proper attention given to the selection of the components of the blend, to be sure that they are compatible. Residual fuels from different sources, particularly those having relatively low viscosities, are not always compatible. Should the oil be made up of a mixture of residual or cracked fuels and straight-run distillates, it may be quite instable, producing heavy asphaltene precipitation in storage tanks. If care is used in their selection, however, no such trouble will occur. For example, the light residuals used in one railroad service test indicated that they could be diluted with as much as 50% of a cracked distillate fuel without such precipitation.

Purifiers and Filters

The next step in making the fuel more digestable for the engine is to reduce the contaminant content to a suitable level. The contaminants—including water and rust—usually found in residuals can cause abrasion or erosion of injection equipment and other internal parts.

In marine operation, water and sediment are generally removed by centrifugal purifiers. Filters can be used alone but, if water is present, filter operation is hampered. Work is, however, being done on filters of the water-coalescing type.

Heating of the fuel may be necessary before it is fed to the centrifuge to bring its viscosity down to 100–200 SSU. For No. 6 oil, the average centrifuging temperature should be about 200 F. With fuels of higher viscosity, temperatures as high as 250 F may be necessary.

For efficient removal of contaminants, two centrifuges may be used in series, or a centrifugal purifier may be followed by a filter. When large quantities of purified fuel are required or a dirtier fuel than usual is to be cleaned, centrifuges having a continuous discharge of solids are sometimes used.

In railroad operation, the fuel may be given a preliminary filtering when it is being transferred from the main railroad storage tanks to the locomotive. Under these conditions, it appears that a single filter element as primary filter on the engine will permit about three weeks of regular road freight service before replacement is necessary.

For final filtration, tests are being conducted on resin-impregnated paper, cotton waste, and other filtering media to determine the degree of filtration necessary to protect the injection system and to obtain maximum service life. As a safety factor, a twin filter element housing is being used in the tests to permit a changeover in service in the event of excessive pressure drop across the filter element.

Another series of tests demonstrates the usefulness of filters. In the first run a completely unfiltered fuel consisting of No. 5 residual cut with 25% No. 1 kerosene was used (to reduce viscosity below 100 SSU, since heat could not be used). At the end of 1750 hr, power and oil control began to be lost. A study of the engine showed that the fuel injection pumps and valves were badly worn, as were the compression rings. The fuel injection equipment wear indicated that insoluble abrasives were a contributing factor.

For the second run a filter containing 8-12-micron paper was used. After 1200 hr, mechanical troubles made it necessary to take down the engine. Inspection showed that the fuel injection equipment wear had been reduced to a satisfactory level. Top compression ring wear was high, but cylinder-liner wear was normal.

It was felt that the top ring wear could be the result of insoluble ash-forming materials, which were not removed by the filter, soluble ash-forming materials, and the residual material.

Fuel Preheating

If the residual fuel has a viscosity too high to give a satisfactory spray pattern, it must be heated sufficiently to bring the viscosity to a workable level.

There appears to be no restrictive temperature limit, from the mechanical point of view. In one case, satisfactory operation was reported with fuels heated to 250 F.

If lower temperatures are sufficient, the engine's own cooling water (which in a locomotive diesel is at 160–185 F) may be used to heat the fuel.

Dual-Fuel Operation

Even on large, slow-speed marine engines, it is necessary to go to a distillate fuel when the ship enters the harbor and maneuvers at the dock. This

The experts who led the discussion on heavy fuels were:

M. J. Anderson, Ethyl Corp. (panel leader)

Gregory Flynn, Jr., Research Laboratories Division, GMC (Secretary)

G. L. Neely, Standard Oil Co. of Calif.

J. L. Broughten, Union Oil Co. of Calif.

C. C. Moore, Union Oil Co. of Calif.

J. W. Vollentine, Caterpillar Tractor Co.

D. M. Landis, DeLaval Separator Co.

R. A. Pejeau, Cleveland Diesel-Engine Division, GMC

Carl Habermann, Socony-Mobil Oil Co., Inc.

J. M. A. van der Horst, Van der Horst Co.

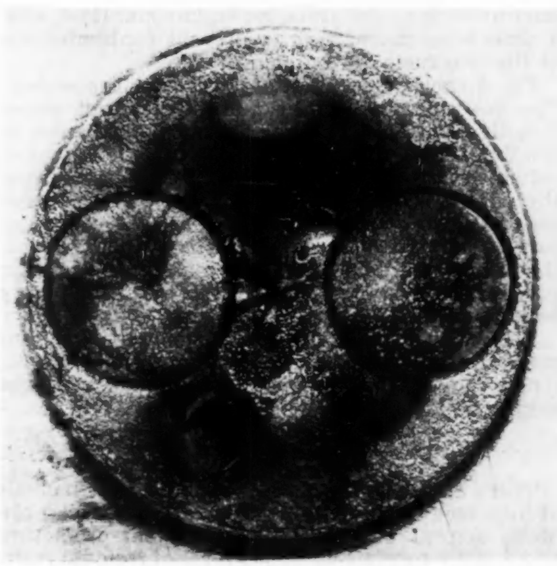


Fig. 1—Head and injector tip condition after light-load operation on residual fuel of 100 SSU at 100 F (Neely).

Fig. 3—Head and injector tip condition after light-load operation on distillate fuel of 38 SSU at 100 F (Neely).

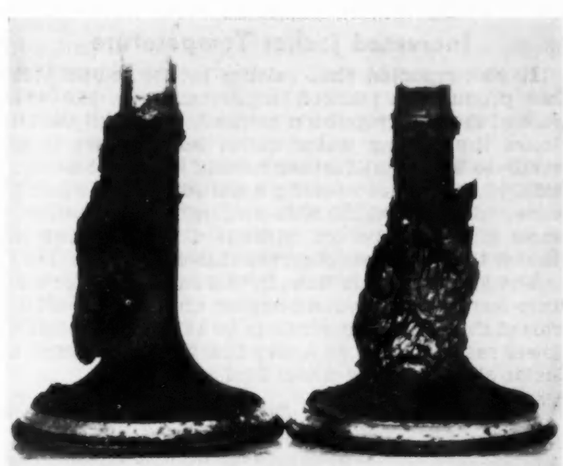


Fig. 2—Exhaust-valve condition after light-load operation on residual fuel of 100 SSU at 100 F (Neely).

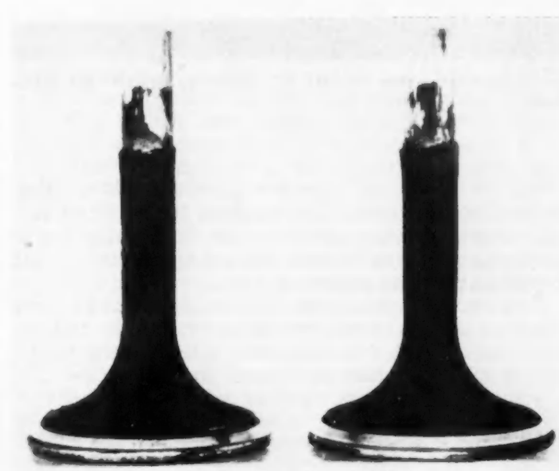


Fig. 4—Exhaust-valve condition after light-load operation on distillate fuel of 38 SSU at 100 F (Neely).

is even more true of locomotive diesels, where, as already mentioned, conditions inside the combustion chamber are less favorable for burning low-grade fuel.

This point is illustrated by Figs. 1 and 2, which show the deposits obtained in the combustion chamber and on the exhaust valve of a test engine operating at part load. A residual fuel of very high quality and only 100 SSU at 100 F was used in these tests. Figs. 3 and 4 show equivalent operation on a distillate fuel. At full load the operation of this engine was satisfactory on both fuels.

The answer to this problem appears to be the dual-fuel system, which allows a switchover to distillate fuel when the load drops below a certain point.

Fig. 5 shows a dual-fuel system developed for the model EMD F-7 locomotive diesel.

In this system, the regular distillate fuel flows from the small tank (200–300 gal) located in the locomotive unit, through a suction strainer to the gear pump, to the string-wound filters, through the sintered metal filters to the injector, with the return to the suction side of the fuel pump.

The residual fuel flows from the main engine tank (1500 gal) through a suction strainer to the gear

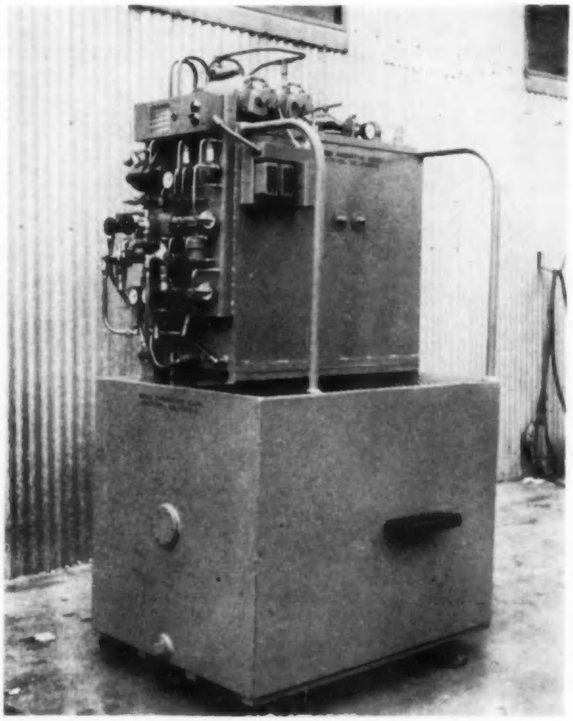


Fig. 5—Dual-fuel system for EMD F-7 locomotive engines (Broughten-Moore).

pump, to the heated primary filter, to a final filter, and to the injectors. The residual fuel in the dual-fuel system is returned from the engine header to the suction side of the residual fuel strainer to aid in preheating the incoming fuel.

This system is designed to circulate about 240 gph, which is about three times as much fuel as the engine requires at full throttle. The system is designed with two selector valves to handle the fuel inlet and the return from the engine manifold, with a time-delay mechanism to prevent contamination of the two fuels during changeover.

Fig. 6 shows a schematic diagram of the system. The hot water for the heat exchanger unit comes directly from the top of the engine at the center of the V at the accessory end of the engine. The water return from the heat exchanger goes directly into the engine coolant expansion tank. Temperature data show that with about 16 sq ft of heat exchanger surface and with a fuel pump capacity of 240 gph, the circulating heat exchanger maintains the main body of fuel in the locomotive tank at a satisfactory temperature.

With about 36 sq ft of heat exchanger surface for preheating the oil to the primary and final fuel filters, it is possible to maintain the fuel at nearly the engine coolant water temperature.

Crankcase Oil

There appear to be grounds for believing that oils of increased additive level (such as Series 2 oils) are often helpful in overcoming the wear-promoting and deposit-forming characteristics of residual fuels. If such oils are not used, and the crankcase oil is found to deteriorate more rapidly than normal, it may be desirable to shorten the oil drain period. Further studies are being made on this problem.

Increased Jacket Temperature

It was reported that raising jacket temperature has produced a marked improvement in the wear rate of marine propulsion engines. Unluckily, many times the cooling water outlet temperature is already so high that further raising it cannot be considered because of working conditions for the engine crew. Sometimes the ship engineer will promise to raise the temperature without actually doing so. Jacket temperatures observed ranged over 131–158 F.

The story was told how, in one instance, a French ship owner with a young engine crew in a new ship raised the jacket temperature to 167 F. He obtained lower rates of wear on heavy fuel than was found in sister ships burning diesel fuel.

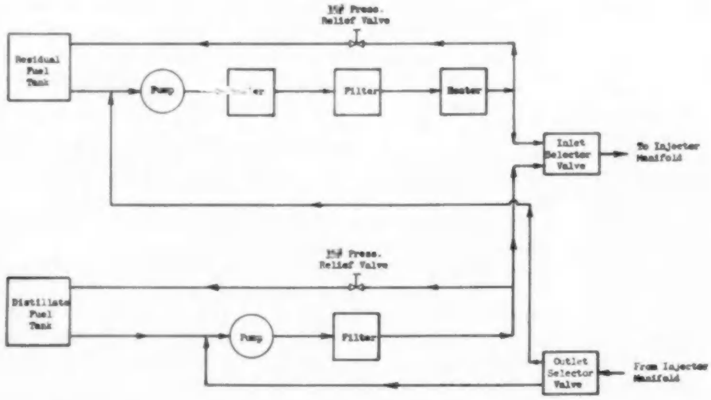


Fig. 6—Schematic diagram of dual-fuel system (Broughten-Moore).

Answers to Today's Piston-Ring Problems

Melvin E. Estey, assistant chief engineer, Perfect Circle Corp.

Excerpts from paper "Piston Rings—Art or Science?" presented at the following SAE Sections and Groups in 1955. Colorado Group, Denver, March 7; Salt Lake Group, March 8; Spokane Intermountain Section, March 10; Northwest Section, Seattle, March 11; British Columbia Section, Vancouver, March 14; Oregon Section, Portland, March 16.

SO long as internal combustion engines use piston rings to seal the piston as it reciprocates back and forth within the cylinder, wear will always be a problem . . . wear of the ring, wear of the piston groove, and wear of the cylinder.

As changes in engine design, operating conditions, and performance requirements have accentuated the wear problem, changes in ring design have been introduced as counter measures. Let's take a look at some of the specific problems which affect the piston ring and the principles that can be applied to solve them.

Problem 1: Ring Wear

Wear, as applied to piston rings, may be classed as abrasive, corrosive, scuffing, or combination thereof. Let us consider separately the various types of wear and how they affect the piston-ring problem.

Abrasive wear comes from two surfaces rubbing together. It is accelerated if this rubbing occurs in the presence of abrasive particles. Engine cleanliness and proper choice of ring and cylinder surface finishes are primary factors in reducing or minimizing abrasive wear. Another factor which can contribute to wear rate is pressure of the ring against the cylinder wall.

Wear rates may be reduced by lowering unit wall pressure. In applying this principle to oil rings, by either increased face contact area or reduced ring tension, the associated effect on oil control must be considered. In applying the principle to compression rings, especially the top one, the pressure behind the ring during the compression and power strokes is a much greater factor than the inherent ring tension; very little can be gained by reducing ring tension.

Another method of reducing wear is to increase the ring width. An increase in width of top compression rings from 3/32 to ⅛ in. was found to reduce the wear rate, on an accelerated abrasive wear test, by some 30%.

This is not always a satisfactory approach for three reasons. First, as the ring width is increased, the scuff resistance is reduced. This is caused by the inability of a wider ring to dissipate heat as readily as a narrower ring. Second, increased width increases the susceptibility to flutter or ring collapse. This is especially a factor where high engine speeds are contemplated. Third, increased width is not in keeping with the current trend toward reduced pin height and narrower ring belts on pistons.

Another method of reducing wear is to use harder piston ring materials. While some gains can be made in increased hardness of the base ring material, much greater gains have been made by applying a hard coating to the ring face. Chromium plate is the current material being used.

Chromium plate is currently applied to several varieties of both compression and oil rings. Its thickness varies from a few tenths, where initial protection only is desired, to 0.010 in. or more for prolonged advantage over a long period in heavy-duty equipment. In a split engine test of over 44,500 miles, the unplated cast-iron top rings wore at a rate about four and one-half times that of the plated top rings. There was no noticeable difference in second or oil ring wear rates.

In an evaluation of tests on a large number of vehicles, operated by different drivers under their own normal operating conditions, relative wear rates of top and second rings were evaluated. The range of wear rates encountered on second rings was the same, regardless of whether or not the top ring was

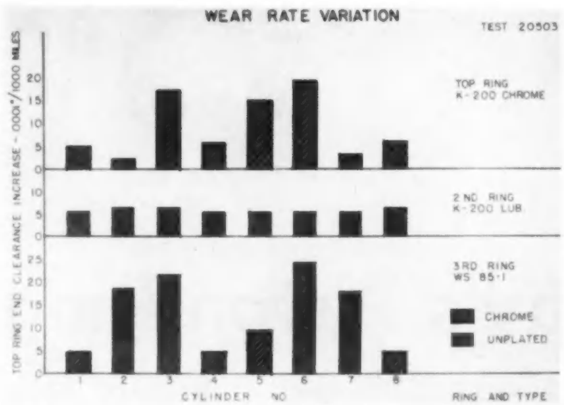


Fig. 1—As these test data show, sometimes there are unknown factors influencing wear in a given engine. In this case, there was no correlation between wear of the top rings, second rings, and the oil rings.

plated. With this condition, it was apparent that the comparative wear rates of the top rings would then be valid. Such a comparison showed the wear rate of unplated top rings to be from 0.46 to 16.5 times that of the plated rings. The average figure was 2.42. These data are for wear rates within individual cylinders.

In this example, in the case of both plated and unplated top rings, as well as second rings, there is a wide variation in wear rates. We don't know why. Tests are currently under way to try to find the answer.

We realize that wear rates in one engine may differ from those in another due to use of different fuels, lubricants, materials, and, of major importance, air cleaners of different efficiencies. When we get wide variations of wear within one engine, however, we think there is some unknown factor at work.

In one test (see Fig. 1), top rings were found to wear at rates from one-third to three times that of second rings, while the second rings in all cylinders wore at a constant rate. In this particular test, half of the oil rings were chrome plated and half were not. The chrome-plated oil ring wore only 30% as much as the unplated oil rings; but there was no correlation between this and the variation in wear of the chrome top rings.

While chrome plating piston rings has alleviated the wear problem, it has in no way eliminated it. The wear problem will always be with us—probably in indirect proportion to our ability to provide more wear-resistant materials.

The second type of wear, corrosion, may be due to carbon dioxide and the oxides of nitrogen and sulfur. Sulfur is considered to be by far the greatest factor and is of major concern to users of high-sulfur diesel fuels. This type of corrosion can be brought under control by selection of lubricating oil having proper corrosion-inhibiting additives.

Corrosive wear is also affected by coolant temperature. At temperatures below 120 to 140 F, the wear rate is greatly accelerated. This is attributed mainly to corrosive action.

Corrosive wear may be minimized—if not entirely eliminated—by selection of low sulfur fuels, lubricating oils with proper corrosion inhibiting additives, and by maintenance of coolant temperatures above the critical level.

The third type of wear, scuffing, may be defined as an abnormally high rate of material removal from one or both of two surfaces in sliding contact with each other as a result of metal-to-metal contact. It is generally believed that scuffing can occur only in the presence of a breakdown in the oil film, and under sufficient speed and/or pressure to generate surface temperatures high enough to permit welding the materials together momentarily in localized areas.

The steps necessary to prove this theory are rather difficult, although quite logical, and the steps that can be taken to alleviate scuffing tend to conform to the theory.

Scuff resistance of gray cast iron is improved as the total carbon content is increased with the graphite or free carbon being distributed in a random or nonpreferential manner. Total carbon, along with increased graphite, can be carried to such an extreme that other properties, mainly strength, suffer. Free ferrite, under any condition, is not conducive to maximum scuff resistance.

The use of narrower rings will improve scuff resistance by providing for more rapid heat transfer from the ring face. The use of this technique is limited by the required resistance to axial loads and can only be at the expense of a somewhat higher normal wear rate.

Interruption of the face of rings is often used as a method of obtaining greater scuff protection. In

Three Ways of Interrupting Piston-Ring Face Surfaces

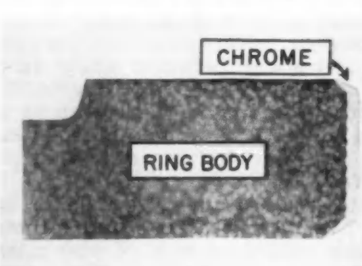


Fig. 2—The face of this chrome-plate compression ring has a thread finish.

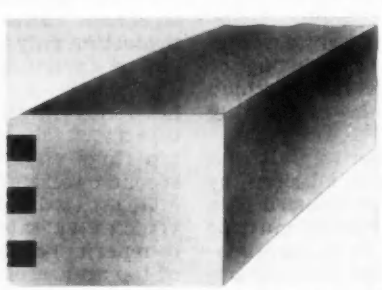


Fig. 3—The face of this ring was grooved and filled with magnetic iron oxide.

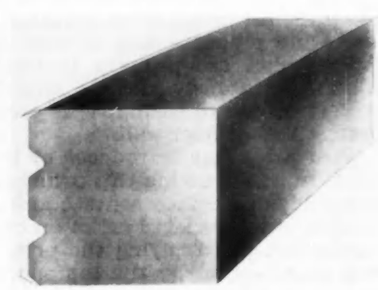


Fig. 4—For greater scuffing resistance, rings can be grooved and then chrome plated.

general terms, interruption of a surface prevents the spread of localized surface disturbances, provides additional area for rapid dissipation of heat from localized areas, provides additional lubrication to localized areas, thus further assisting in heat dissipation, and allows independent expansion and contraction of localized surface areas. Care must be exercised in the use of interrupted surfaces on piston-ring faces, however. If carried to extreme, such a procedure may contribute to excessive oil consumption or blowby.

Surface interruption is used in rings in several ways. The thread finish on the ring face, shown in Fig. 2, is a common one and is used on both plated and unplated rings. In the case of the plated rings, the top of the tool marks are flattened by the face lap process which is required on chrome rings to provide a satisfactory run-in period. Grooves in the face of the ring, Fig. 3, also provide an interrupted surface. In this case, the grooves are filled with a magnetic iron oxide whose function is mainly to fill the groove and prevent excessive oil consumption.

Chrome plate in itself affords some additional scuff resistance over that of unplated rings. This is generally considered due to the increased surface temperature at which chrome can operate before welding to the mating material. Where the application of chrome over a normal tooled surface is not sufficient protection, the face may be grooved, as in Fig. 4, to further assist in protection against scuffing. This particular design is applied only to two-stroke cycle diesel engines where it doesn't seem to affect oil economy.

Scuffing, being a function of temperature, may be reduced by lowering the top ring location. This is generally not feasible on automotive type pistons where the resultant increase in pin height would be objectionable. It is common practice, however, in heavy-duty applications, where space is generally not at such a premium.

There are numerous ring coatings used today which give various degrees of increased initial scuff protection. Ferrox, Parco Lubrite, tin plate, and cadmium plate are among the more common. They are of major value during run-in, since, with a small amount of ring face wear, they are no longer present.

Problem 2: Oil Control

Almost without exception, we can say that oil control is a function of unit pressure of the oil ring or rings. Whenever an engine is found to suffer in this respect, it is common practice to increase the unit pressure. However, the oil ring can do only so much, after which the compression rings must furnish the remainder of the control.

Compression ring face attitude is of maximum concern in this respect. A compression ring may exhibit full face, center, or lower edge contact without penalty. But any tendency toward top corner contact to the exclusion of face contact elsewhere, and the resultant upward scraping action is not conducive to the best oil economy. In this respect, a new ring type is now being used, the taper face torsionally twisted compression ring, shown in Fig. 5.

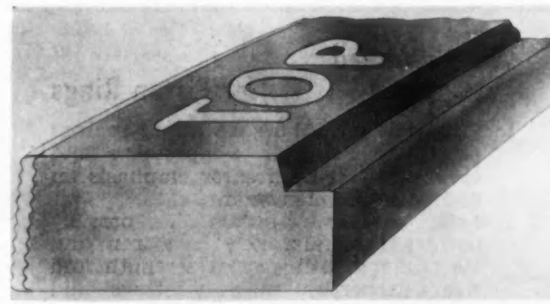


Fig. 5—To get around the tendency of a compression ring's top corner to produce upward scraping without face contact, this taper face, torsionally twisted ring was designed.

It has found its major acceptance where 5/64-in. width rings are used.

The narrow width rings are more prone to dish, due to pressure, in a downward direction, thus exhibiting top corner contact. The advantage of the taper face ring, combined with that of the torsionally twisted ring, overcomes this characteristic.

In recent months, a new problem has occurred in several of the newer model cars. Engines which have good oil control characteristics at normal road load or higher power conditions, use excessive amounts of oil under high vacuum conditions, such as on steep down grades or closed throttle deceleration.

We attribute this loss of oil control, under high vacuum conditions, to the fact that deceleration vacuum increases with compression ratio.

Test results show that this difficulty can be overcome by use of a ring design in which a positive seal is made against the side of the groove as well as against the cylinder wall, thus preventing or reducing the amount of oil which may pass around the ring during the vacuum stroke.

Problem 3: Ring Groove Wear

Ring groove wear is a relatively common problem, particularly in heavy-duty equipment and wherever insufficient cooling occurs. It is generally acute only in top grooves. There, some 90% of it occurs on the top side of the groove. It is caused by abrasives, inertia loading, temperature, or combinations thereof.

In the absence of abrasive wear, high temperature is considered to be the main factor contributing to groove wear, particularly in aluminum pistons. High temperature may act in two ways in this respect. First, it affects lubrication, and, in the presence of lesser amounts of, or less effective lubrication, wear may be accelerated. Second, higher temperature may result in a sufficient softening of the material in the top land, increasing its susceptibility to wear.

Cast-in top groove inserts, shown in Fig. 6, are coming into wide use as a means of reducing top groove wear. Made of cast iron or Ni-resist, they have more resistance to wear than aluminum, particularly at elevated piston temperatures. Success-

What's Ahead for Piston Rings

1. **The trend toward higher output engines** (with their higher compression and speed) will bring greater emphasis on high vacuum oil economy.
2. **Look for new materials . . .** possibly powdered metals; new cast iron and steel alloys with special strength and wear properties; new coastings and facings. Materials harder than chromium now are under test.
3. **We're fast approaching** the short-stroke, large-bore engine. To accommodate its low pin heights and narrow ring belts, we'll have to get by with fewer rings per piston and/or narrower rings.
4. **Longer life** will be required of an engine and its components. It's common to hear of passenger car engines running 60,000 to 80,000 miles before the first overhaul. Piston rings will have to last longer than that in the future.

ful application of this technique depends upon the ability to retain the insert tightly in place in the piston throughout its life. Ni-resist is of value in this respect in that it has a coefficient of expansion substantially equal to that of aluminum, while the coefficient of expansion of cast iron is about half that of aluminum. Use of Ni-resist, therefore, reduces the thermal stresses at the bond line, lessening the chance of the insert becoming loose in the piston.

Right now the cast-in groove insert piston is costly. To date it has been applied only to heavy-duty truck and bus engines, where the additional cost can be offset by the resultant increased piston and ring life.

Some ring manufacturers are now furnishing a re-grooving tool for salvaging worn grooves. This tool re-machines a badly worn groove to a great enough width so that a steel spacer can be installed above the new top ring. In effect this produces a new unworn groove. It is said to provide some extra side wear protection during subsequent operation.

We occasionally find engines in which the top groove side wear is not uniform. In such cases, maximum wear is usually found at a piston location corresponding to an area of the cylinder where poor or inadequate cooling exists or adjacent to the spark plug location. The effect of nonuniform top groove wear can be severe. Such a condition, together with impact of the ring against the side of such a groove, can easily contribute to ring breakage.

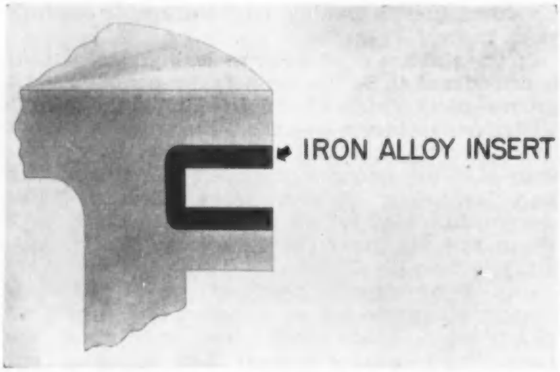


Fig. 6—Cast-in iron inserts help reduce groove wear.

Problem 4: Cylinder Wear

Cylinder wear is aggravated by abrasives, corrosive action, and scuffing, much the same as rings. The same general thoughts apply as to methods of wear reduction. Thus, we may infer that wear can be reduced by use of chrome plated cylinders. This is the case, but is seldom used in practice since the cost is high. Substantially the same reduction in cylinder wear rate can be obtained by using chrome-plated top rings. In the split engine test, where top ring wear rate of unplated rings was 4.5 times that of plated rings, the cylinders having unplated top rings wore 2.5 times as much as those having chrome-plated top rings. In another case, cylinder wear was 3.3 times as high in cylinders having unplated top rings as in those having chrome rings.

In a study of average cylinder taper increase on 102 vehicles, the average wear rate of cylinders having unplated top rings was 2.3 times that of cylinders having plated top rings.

Problem 5: Cylinder Irregularity

Cylinder geometry is a factor over which the ring manufacturer has little or no direct control, but with which he is vitally concerned. Piston rings, to perform at maximum efficiency, must conform

Fig. 7—This cylinder contour gage has made it possible to measure cylinder irregularities.

to any and all cylinder irregularities. Cylinder irregularities, or deviations from a perfect cylinder, may be due to any of these three major causes:

a. Machining imperfections b. Wear c. Distortion

Some years ago, we designed and built a gage for studying cylinder geometry. It's shown in Fig. 7. This gage has a 0.0001-in. reading dial indicator mounted on the lower end of a $2\frac{1}{2}$-in. diameter gage shaft. The gage shaft is hollow for optical observation of indicator movement. The shaft is mounted in a base casting in such a way that it may be accurately centered within the cylinder, and then rotated and reciprocated throughout the cylinder to measure radius variations at any cylinder wall area. Studies can thus be made of wear patterns and machining variations and distortion characteristics.

For studying the effect of forces of a head assembly, a 3-in. diameter hole is bored through the cylinder head, and then the head is applied in normal manner. The gage shaft may then be inserted into the cylinder through the hole and distortion characteristics determined.

Figs. 8, 9, 10, and 11 show some examples of the cylinder irregularities we found with this gage.

For complete paper (in multilith form) on which this abridgment is based, write SAE Special Publications. Price: 35¢ to members, 60¢ to nonmembers.

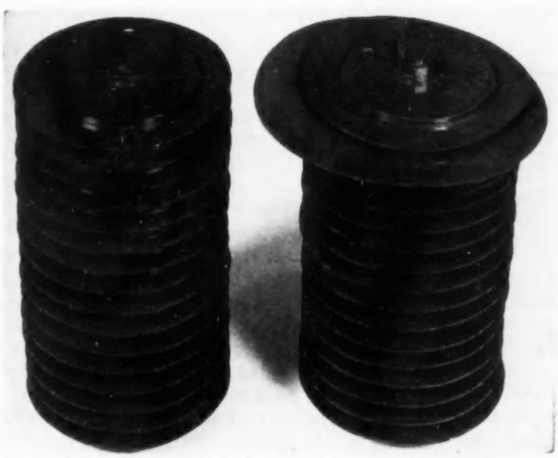


Fig. 8—The model at left is that of a cylinder with almost perfect geometry. At right is the same cylinder after some 50,000 miles of normal road operation. The major wear, on one side of the cylinder, was assumed to be due to unequal application of combustion pressures around the piston because of a top deck relief in the valve area.

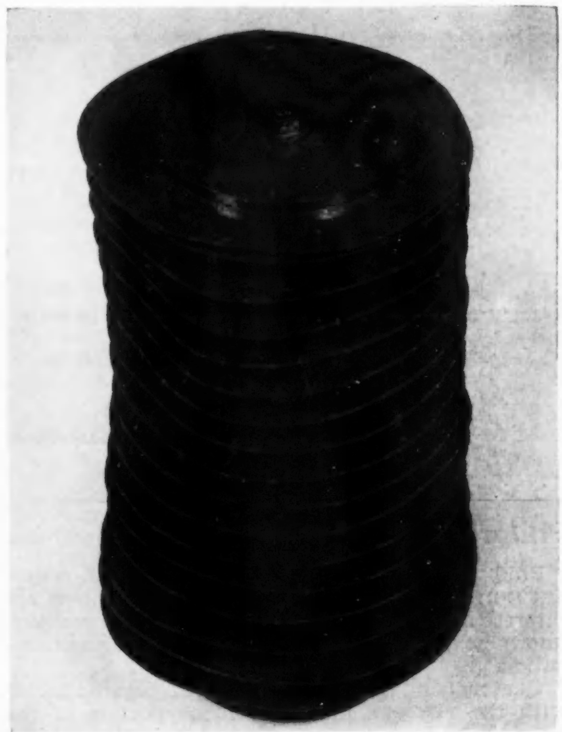


Fig. 9—This three-dimensional model of cylinder shows the radial variations from a true circle magnified 300 times. This particular triangular shape is due to machining variation. The cap screw bosses, tied to the cylinder, provide sufficient rigidity for a full metal cut during honing. In the relatively unsupported areas between the bosses, a full cut is not taken.

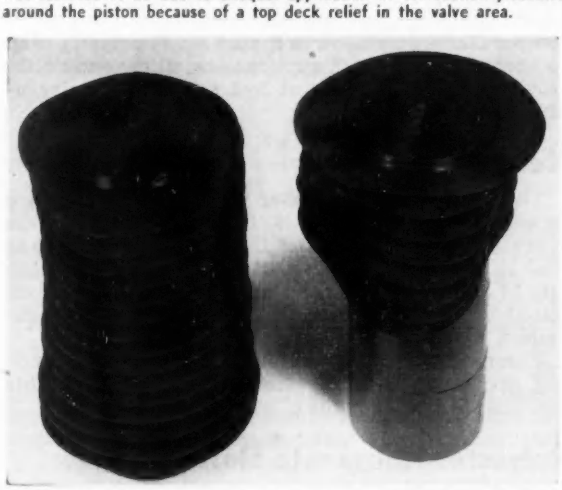


Fig. 10—At left is the contour of a cylinder before the head was in place. At right is the top $3\frac{1}{2}$ in. of the same cylinder after the head was installed and normal torque applied. The distortion, amounting to about 0.004 in. of radial variation, was due to a combination of upward cap screw tension on the bosses and downward gasket pressure in the relatively unsupported top deck areas between bosses. Now look at Fig. 11.

Fig. 11—This is the same cylinder as in Fig. 10. But in this case, the mating surfaces between head and block were ground flat and smooth before putting on the head. The gasket was omitted. This improvement points up the importance of head gasket design.

Elastomers

Recent research in elastomers has resulted in many new and improved synthetics. Among these are:

- Philprene VP
- Polyacrylic rubbers
- Kel-F elastomers
- Polyester-Isocyanate elastomers
- Hypalon
- Vinyls
- Silicone rubber
- Buna S (GR-S)
- Butyl rubber
- Neoprene
- Buna N
- Carboxylic elastomers

Philprene VP

Philprene VP is one of a new family of **oil-resistant** synthetic rubbers. These synthetic rubbers are interesting because they utilize a chemical reaction known as quaternizing to assist the regular vulcanization.

Quaternizing is done by reacting an organic halide with the nitrogen in the pyridene portion of the polymer to form a type of structure which apparently makes the polymer oil resistant. The organic halide is added during the regular mixing operation on the mill and the reaction takes place during the regular vulcanization.

According to the manufacturers of this material, sulfur vulcanization does not enhance the oil and fuel resistance of Philprene VP to any great extent, but the quaternizing reaction definitely changes the mixture to an oil resistant compound.

Polyacrylic Rubbers

Outstanding features of two new polyacrylic rubbers include:

1. Low swelling
2. Low shrinkage
3. Oil resistant
4. Resistance to extreme pressure lubricants
5. Fire resistant
6. Heat resistant

The addition of flourine in Poly F.B.A. seems to have produced a rubber with low swelling characteristics in oils and fuels with substantial aromatic content, along with low shrinkage in high aniline point oils. Like standard polyacrylic rubbers, the new fluorinated type also has the drawback of rather poor low temperature properties.

Preliminary tests in the Chrysler Rubber and Plastics Laboratory have indicated that this material possesses remarkable resistance to oils (both low and high viscosity), extreme pressure lubricants, fire resistant hydraulic fluids, and dry heat. Its present price is extremely high and to some extent its acceptance will be determined by its ultimate production price.

N5400 Elastomer is an exploratory material of an acrylate type recently developed by the Monsanto Chemical Co. It was developed specifically to withstand fire resistant hydraulic fluids such as Skydrol. Like other acrylate type rubbers it is not flexible at temperatures much lower than 0 F. It is being used in specialized aircraft applications where its ability to withstand fire resistant hydraulic fluids is valuable.

Kel-F Elastomer

This new synthetic rubber has unusual **resistance to corrosive chemicals,** oils, fuels, extreme pressure lubricants, and many other fluids. It can be vulcanized to form compounds with high tensile strength (up to 3800 psi), and good tear resistance. It is reputed to have exceptional heat resistance, and excellent weather and ozone resistance.

These characteristics combined with its outstanding resistance to many fluids make it a valuable material for many kinds of seals.

Polyester-Isocyanate Elastomers

Solid Polyester-Isocyanate rubbers have received considerable publicity because of their **"super" elastomer** properties. The characteristics of this new elastomer that have caused so much excitement are greatly increased tensile strength (measurements up to 7000 psi have been made) and greatly in-

Are Improving

W. J. Simpson, Chrysler Corp.

Based on paper "New and Improved Synthetic Elastomeric Materials for Automotive Use" presented at SAE Golden Anniversary Passenger Car, Body, and Materials Meeting, Detroit, March 1, 1955.

creased resistance to abrasion as measured by tire tread wear. In addition, the new rubber has good resistance to flexing and weather, along with reasonably good oil resistance.

While the good properties of this material are being considered, one must not forget that it still has some deficiencies. Under steady load (such as in mountings), it exhibits considerable cold flow and deformation. Its strength drops off considerably at 200 F, or higher, as does its oil resistance. Its resistance to steam and hot water is poor.

The development of Polyester-Isocyanate solid type rubbers has been slower than that of the foam type because manufacturing processes are difficult to control.

Hypalon

Hypalon is a new rubber-like plastic which has unusual **resistance to ozone** and a great variety of chemicals. Since compounds with good properties can be made without the use of carbon black, it is possible to produce almost any desired color.

This material has been applied to the manufacture of spark plug covers where considerable corona discharge and heat are encountered.

Vinyls

The **excellent cleaning and wearing** qualities of vinyls, in addition to their molding properties, have led to the development of two new applications for this material.

A vinyl coating applied to rubber mats during the manufacturing process produces very beautiful mats enhancing the interior styling of automobiles. It also gives a surface with very good wearing qualities and one that can be easily cleaned to maintain its good appearance for a long time.

In another new application, arm rests using foamed vinyl integrally molded with an embossed vinyl skin have been made to form a very attractive interior part of the automobile. This has eliminated the necessity of trimming the sponge arm rest as a separate operation.

Silicone Rubber

Enhanced **low temperature flexibility** and increased **high temperature serviceability** are the anticipated results of a new silicone polymer.

Due to its chemical makeup, this polymer can be blended with Buna N, Buna S, or other elastomers. This achieves compromise properties in compounds made from the lower priced and stronger organic type rubbers.

Buna S (GR-S)

The development of so called **"artic rubbers"** has resulted in increased use of the special GR-S elastomers in military aircraft applications requiring serviceability at − 65 F.

Tremendous strides have been made recently in the art of compounding Buna S, particularly in the use of super fine furnace process carbon blacks and also in the use of so called "oil extended" polymers. The development of the "cold rubber" process of polymerization (polymerizing at temperatures just above the freezing point of water) has resulted in the production of stronger and more abrasion resistant rubbers.

The art of blending substantial quantities of low cost petroleum plasticizers with the latex of high viscosity polymers has resulted in the development of the "oil extended" GR-S elastomers achieving not only a saving of cost, but an actual improvement in quality in some cases.

Butyl Rubber

A new type of butyl polymer has been announced. This is a polymer that has been modified by introducing 1 to 3½% bromine. This bromine modified butyl is **not contaminated** by ordinary sulfur vulcanizable rubbers. It can be mixed with them or vulcanized adjacent to them and still be satisfactorily cured.

This type of butyl rubber is still too new to have been evaluated, but it should prove to be advantageous in parts where it might be desirable to blend it with other elastomers or to make assemblies containing both brominated butyl and other elastomers, provided its ultimate price is not too high.

Neoprene

Recently a new type of neoprene known as WHV has been developed. This is a high viscosity W type neoprene, to which very large quantities of low cost

petroleum type plasticizer may be added during the mixing operation. Compounds made from this elastomer have physical properties that are adequate for a number of applications, and at the same time have the advantage of **lower cost** than standard neoprene compounds.

Their use should be advantageous in applications where possible plasticizer extraction from the neoprene compound by fluids is not a problem, or in applications where fluid resistance is not required.

These types of compounds are being used in parts such as dust seals where any occasional splashing with oil or other fluids is encountered, and in applications where the excellent weather resistance of neoprene is desirable.

Buna N

By varying the ratio of butadiene and acrylonitrile it is possible to produce a number of varieties of Buna N with varying degrees of **resistance to oils and fuels** and with varying degrees of **low temperature flexibility.** The art of compounding Buna N has been improving and compounds are now available for seal applications requiring resistance to oils at temperatures up to 300 F.

A tremendous amount of "O" rings, lip type seals, rotating shaft seals, and other types of seals are being made from Buna N for use in engines, transmissions, differential carriers, power steering units, and many other hydraulic applications.

Carboxylic Elastomers

Recent modification of standard Buna S and Buna N synthetic rubbers by chemically introducing small percentages of carboxyl groups results in elastomers with **greatly enhanced physical properties,** improved oil and fuel resistance, and increased useful temperature range.

These types of rubbers are vulcanized by crosslinking the carboxyl groups or by the use of sulfur.

For complete paper (in multilith form) on which this abridgment is based, write SAE Special Publications. Price: 35¢ to members, 60¢ to nonmembers.

Lower Silhouette . . .

. . . is possible with revised drive line. But new configuration must be checked carefully to insure that it doesn't excite objectionable vibrational disturbances.

Based on paper by **R. R. Burkhalter and P. J. Mazziotti,** Universal Joint Division, Dana Corp

PASSENGER car styling considerations on new cars demand reduced height to produce this low silhouette design that is the vogue. To achieve this reduced height, several possibilities are available. The roof can be lowered close to the seats; however, a practical limit has already been reached. Ground clearance can be reduced by reducing tire diameter or lowering engine and other mechanical parts of the car closer to the ground. Some lowering at this point will probably be accomplished; however, cars must still be able to clear a reasonable ramp angle and clear obstacles without danger to the under portions of the car. Outside of reducing clearance, the drive line of a car must be lowered in order to lower seats and floor line. A revised drive line configuration which allows a lower tunnel and floor can help accomplish the required lowering of the entire car.

The drive line must transmit torque from the engine located at the front of the vehicle to an axle located at the rear driving wheels if our present passenger car configuration is to be maintained. This might, of course, be revised to a front wheel drive car or a rear engine car at some time in the future; however, this paper will generally deal with the problem involved in the conventional arrangement.

The typical passenger car of today uses a single piece propeller shaft equipped with two universal joints to connect the transmission to the axle pinion. The two universal joints are generally of the conventional Cardan or cross type. These universal joints operate through comparatively small joint angles in the running position. This type of universal joint has unusual nonuniform motion characteristics which can present some problems.

Present passenger cars with generally small joint angles and reasonably long-length propeller shafts keep the resulting excitations down to a level where they are usually not troublesome. With this arrangement, generally satisfactory drive lines have resulted despite the nonuniform motion characteristics. Under instantaneous conditions of metal to metal and full rebound, considerable excitation is often present; however, these are usually not noticeable.

Some lowering of car height might be done by merely using larger joint angles. This could allow a tipping down of the axle pinion and a lowering of the rear of the engine to accomplish a lower tunnel height. This usually cannot be done due to the higher excitation forces present due to larger joint angles. A revised drive line configuration can accomplish the desired lower tunnel and floor if proper consideration is given to maintaining excitation within reasonable limits. There are many possibilities along this line. To accomplish as much lowering as possible, the excitation must be more carefully controlled to allow as much as can be absorbed without objectionable disturbances. To accomplish this a more complete study must be made of the various types of excitation and their effects.

For complete paper (in multilith form) on which this abridgment is based, write SAE Special Publications. Price: 35¢ to members, 60¢ to nonmembers.

CRC Group Analyzes Exhaust of Cars Operated on L. A. Freeway

Study is part of program to determine the degree to which vehicle exhaust contributes to smog, and how it can be minimized.

OVER 50 cars were road tested on the Harbor Freeway in Los Angeles last December by CRC to study new methods of analyzing vehicle exhaust smoke.

This test project is an important part of the overall air pollution research program being carried on cooperatively by the automotive and petroleum industries.

Charles M. Heinen, of Chrysler, leader of the CRC group studying exhaust gases, said the new analytical equipment and procedures being road-tested were specially designed for a comprehensive survey of exhaust emissions in the Los Angeles area to be made at a later date.

Heinen said his group was formed to answer three questions:

1. How can motor vehicle emissions be measured adequately?
2. To what extent will engine adjustments affect emissions during the various engine cycles?
3. What are the amounts and types of emissions from cars as they are driven in the field?

The most recent tests constitute an initial attack on the third question.

Basic research in Los Angeles, Heinen pointed out, has determined that certain organic substances of motor vehicle exhaust gases contribute in some degree to the local smog condition. As a result, he said, practical means for substantially reducing these critical emissions are being vigorously sought by the industries concerned.

"But before we can complete this work," he explained, "it is necessary to have absolutely accurate data on the amounts and types of emissions actually produced by Los Angeles traffic. Sampling exhaust gases in the laboratory is not enough. For the final answers, emissions must be analyzed continuously through all engine cycles as cars are driven under conditions typical of the area."

Equipment and procedures capable of making such an analysis did not exist until the laboratories of 18 automotive and petroleum companies, in a concerted effort, started to work on the problem less than a year ago.

"Reasonably good analytical tools were available for measuring organic emissions in the idling and cruising stages of operation," said Heinen. "But adequate instruments for analysis during the transient cycles of deceleration and acceleration were lacking.

"The new methods developed have been evaluated on the dynamometers of about 10 cooperating companies, and we are reasonably certain of their accuracy. Through the field test, we expect to overcome problems of adaptation."

More laboratory work on instrumentation still remains, but the field test project was started in order to speed up the overall program as much as possible.

Supervising the test operations was Gilbert Way, leader of CRC's field survey panel.

Way said "The current project is a preliminary survey of a limited number of cars—actually a test to find out if we know how to conduct such a survey."

Exhaust gas samples were obtained in a necessarily meticulous manner and analyzed for constituents which are generally agreed to be of greatest importance in an air pollution investigation.

These include:

1. Organics—unburned or partially unburned fuel.
2. Oxides of nitrogen.
3. Carbon monoxide and carbon dioxide.

Mass spectrometers and infrared spectrometers—instruments for analyzing the composition of gases by means of color bands—were used in the tests. Specially developed instruments for making contin-

uous analytical records from the exhaust stream of a moving vehicle and a new type of engine airflow meter also were tested.

About 50 to 60 cars, of assorted ages and makes, were loaned by Los Angeles residents for use in the tests. A test staff of some 25 engineers and technicians from various companies of the automotive, petroleum and related industries was assembled.

The general test procedure was as follows:

The special test equipment was installed in each car individually and exhaust samples were taken as the engine idled. Then each car was driven south on the Freeway with a test crew of four men. Samples were taken throughout the full range of driving situations—acceleration, cruising, deceleration.

On the Freeway, the sampling operator rode in the trunk of the car and had telephone contact with the driver. Samples were analyzed and results calculated immediately.

Tire Traction . . .

. . . on snow and ice has been improved with new devices. Wire coils embedded in tread prove best of the lot, but nothing yet equals the effectiveness of reinforced chains.

Based on paper by **A. H. Easton,** University of Wisconsin

DRY pavement performance on wet ice is the ultimate goal of those seeking to improve tire traction. To this end they have tried various tire tread patterns and treatment, material embedded in the tread, and sanders.

One method of tire treatment is to operate the tire on rollers having radial projections approximately 3/16 in. high which pierce the tread to leave innumerable small holes. The effectiveness of this treatment is shown in Table 1 where the performance of a tire so lacerated is compared with a regular tire. A second method is to cut or sipe the tread at regular intervals to the depth of the tread root. This is less effective than lacerating as Table 1 shows.

Table 1—Comparative Ratings of Passenger Car Tire Traction Test Tires on Rear Wheels

Tire	Ice 20-25 F Driving	Ice 20-25 F Braking	Ice 20-25 F Cornering	Hard Packed Snow Driving	Hard Packed Snow Braking
Regular	100	100	100	100	100
Lacerated	157	120	109	134	128
Siped	99	118	106	105	123
"Knobby" tread	105	100	102	126	129
Continuous bold	140	122	106	171	133
Wire inserts (dry ice)	172	111	110	147	116
Wire inserts (wet ice)	266	124	—	—	—
Salt in tread	123	111	107	107	106
Peanut shells in tread	96	101	101	73	90
Sawdust in tread	100	103	—	89	99
Round chains	331	197	(a)	—	130
Reinforced chains	509	253	(a)	413	158
Sanders	370	116	—	132	100

(a) Limited by cornering ability of the front wheels.

Table 2—Comparative Ratings of Regular Truck Tires and Those Containing Metal Inserts, Test Tires on All Wheels

Tire	Wet Ice Driving	Wet Ice Braking	Hard Packed Snow Driving	Hard Packed Snow Braking
Regular	100	100	100	100
Wire coils (straight rib)	171	110	—	—
Wire coils (serpentine)	464	172	117	131

Tread patterns have progressed from the "knobby" to the continuous rib type, the ribs becoming more bold by reduction in their number from five or six to two or three. This design change has greatly enhanced traction.

The embedding of metal inserts in the tread has been practiced with indifferent success for at least 15 years. A recent development gives more promise. Each rib of the time contains a circumferential wire coil. As the tread wears, the top of each coil wears off to expose two points per coil. Because the wire is not bonded to the rubber, each point projects when braking or driving traction stretches the tread. In earliest types the ribs were straight. The latest type has a serpentine tread which distributes the action of the wire points across the width of the tread. Table 1 shows performance of the wire insert passenger-car tire on dry and wet ice, while Table 2 shows the effect of the straight and serpentine treads obtained with 10.00×20 truck tires.

Another practice has been to add materials to the tread, such as sawdust, steel wool, or cork, to name a few. The additives themselves are not always effective, but some increase in traction is obtained from the voids left when the material falls out.

Round tire chains are effective and the reinforced type is even more so. The latter also has better wearing qualities. The emergency type which fastens with a strap through the wheel felloe is effective for traction, but unreliable for braking. If the wheel is braked when there is no link in contact with the ground, the vehicle may slide. It is even more dangerous if one wheel engages and the other slides. This sets up unequal braking forces to cause a skid.

Automatic or semi-automatic sanders which feed a stream of sand ahead of the drive wheels are most effective at speeds which don't blow the sand away from the contact area of the tire. Table 1 shows the effectiveness of sanders to be between that of wire inserts and tire chains. (Paper "Progress in Tire Traction" was presented at SAE Golden Anniversary Transportation Meeting, St. Louis, Nov. 2, 1955. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Our Best Trucks Have

Compatible Power Train Elements

C. B. Rawson, Commercial Car Journal

Based on secretary's report on Round Table "Power Train Compatibility" held during SAE Golden Anniversary Summer Meeting, Atlantic City, June 16, 1955.

POWER train compatibility should be a No. 1 aim of the truck chassis designer. He should keep constantly in mind that profit to the operator depends, to a large extent, on proper matching of the various units of the power train. As discussed here, these include:

- The engine.
- The transmission.
- The propeller shaft.
- The rear axle.

. . . And driver controls.

Engine

If the truck is being designed for use in metropolitan deliveries, for example, a high-horsepower engine would be undesirable. The slow, stop-and-go characteristics of city traffic make extra speed unnecessary. In this instance, money spent on a large engine would be wasted.

On the other hand, a truck crawling up a long hill on a 2-lane highway is always a headache to drivers behind it. Passing is frequently impossible, and traffic jams usually result.

A truck being designed for this type of operation needs plenty of horsepower to allow it to go up the hill fast enough. What is "fast enough" is, however, not always easy to decide. Compromises are necessary. To keep up with autos a truck of 25,000-lb gross vehicle weight would require about 1500 hp. Truck horsepowers as high as this are not now available.

If the horsepower is increased only slightly, the truck's speed on level ground will increase. In city traffic a high maximum speed is undesirable and unnecessary. A conventional engine governor would slow the truck both on the level and when climbing hills. Some kind of 2-speed governor should be installed so that more power is available when climbing hills.

Most truck engines are designed for a maximum power output at any speed. Whether the operator wants the extra power or not, he's getting it at the expense of fuel economy and regardless of the load. Truck manufacturers could remedy this condition by changing the engine design.

As speed increases, more and more fuel is wasted in overcoming friction. Most engines show their best fuel economy in the midspeed range and at loads less than the maximum.

Sometimes a choice must be made between a high-torque, low-speed engine, and a low-torque, high-speed engine. For a given horsepower, a large engine operating at low speed uses less fuel than a small engine operating at high speed. The larger, high-torque engine therefore is cheaper to operate. The large engine, however, requires large gears, shafts, and other power train components. These large parts make the high-torque engine initially more expensive than the low-torque engine.

Many designers believe that an engine with the same torque at any speed provides the best truck performance. This belief is not quite correct. In a constant-torque engine, a gear ratio change of only 1.29 results in a change of 29% in available horsepower. Fluctuating horsepower is certainly not good performance.

From the standpoint of flexibility in gearing, trying to obtain constant horsepower seems more important than the goal of constant torque.

Most horsepower increases recently have been the result of higher rpm's. Consequently, the power output has been far from constant. Increasingly

complex power train components have been needed. The actual horsepower put through these components is an important factor in determining their sizes.

A careful correlation or compatibility is required between a particular engine and, for example, its transmission.

Transmission

The transmission permits the engine to operate at or near its peak horsepower no matter how fast the truck is going. The actual truck speed and acceleration depend on how much load the engine has to haul.

If the truck is to be used mostly for city deliveries a rugged transmission is necessary. Stop-and-go engine operation considerably strains the transmission and other power train components.

A light truck will climb a hill faster than a heavy truck, for a given horsepower. The heavy truck requires more gear ratios and therefore a larger transmission.

A low gear ratio is used to start a loaded truck and to get it up hills. Intermediate ratios are used to get the truck up varying inclines at various altitudes with a minimum loss in truck speed.

On the West Coast, trucks lose considerable power because of the altitude. Large transmissions with many gear steps are needed. Turbosupercharged engines are coming into use, however, which reduce the transmission size required.

One controversial subject is the number of intermediate speeds necessary between the lowest truck speed (associated with the lowest gear ratio) and the maximum truck speed. The size of the step between each gear ratio is also open to debate.

The drop in output power at the shift should be used to indicate the sizes of steps required. In this way, engine characteristics are taken into account. Some engines can use large ratio steps, resulting in fewer transmission speeds.

A 55,000-lb 194-gross-hp truck requires a gear ratio range of about 10/1. By using a geometric progression we calculate the engine requires a 10-speed transmission with steps of 1.29, since 1.29 to the ninth power is about 10.

Fig. 1 illustrates how these steps are related to truck speed. Normal power train losses have been taken into account. Note that in the low-speed range, each ratio between speeds results in a large increase in gradeability with little gain in speed. At the high-speed end, however, each ratio results in a small gain in gradeability and a large gain in speed. To obtain maximum speed, therefore, no gear ratio changes should be made at this end.

If the size of each step is too small, the differences between gear ratios become too close and drivers tend to skip steps. At high speeds many small steps are important to provide minor changes in pulling power without too much loss in speed.

Recently, the driving times spent in various gear ratios were investigated. In one test a gradeability of less than 2%, corresponding to a transmission reduction of about 1.75/1, occurred for 70% of the total driving time. If gear ratios must be changed

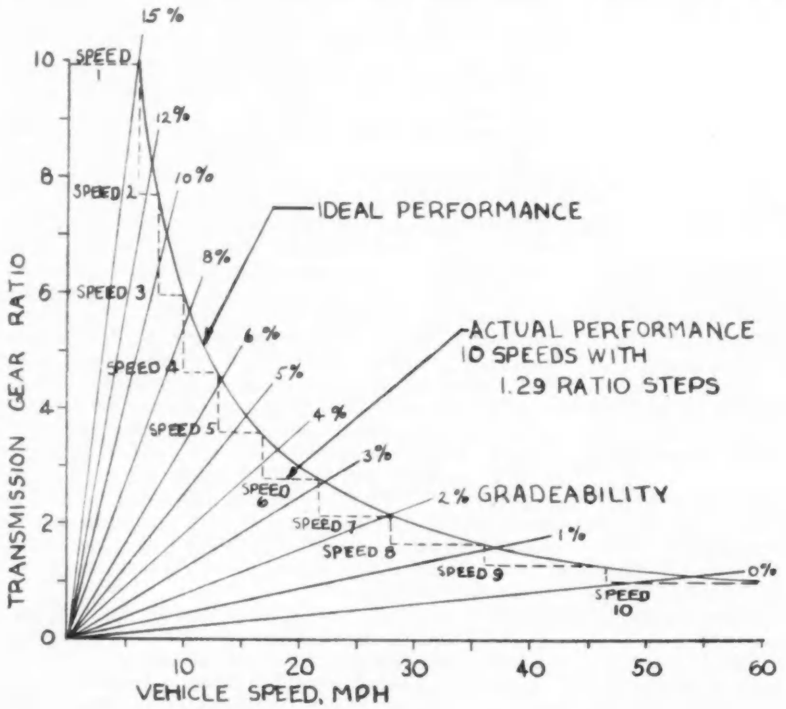


Fig. 1—Transmission gear ratios compared with truck speeds and gradeabilities. (55,-000-lb gross weight, 80-sq-ft area, 194 gross hp).

they should be changed in the lesser used gear ranges.

The value of automatic truck transmissions is still debatable. Conventional transmissions provide highly efficient operation. Automatic transmissions will have to equal or exceed conventional transmissions both in performance and economy to be accepted by the industry.

Propeller Shaft

Truck engines are now being governed at about 4000 rpm. Unfortunately, the governor doesn't operate when the truck is going down hill. Therefore propeller shafts must hold together at very high speeds. Shafts have failed when their critical speeds were surpassed on hills.

"Whip" occurs at a critical speed when the rpm of the shaft equals the natural frequency of transverse vibration, if the shaft is considered a beam supported at its bearings. Every shaft has critical speeds at which the amplitude is limited only by damping.

To have a high critical speed, the shaft must be both light and rigid. Aluminum is impractical because it isn't rigid. Also, aluminum can't be joined cheaply and easily to the steel parts of the universal joint. Thin-wall steel tubing is the answer.

Sometimes $4\frac{1}{2}$-in. diameter tubes are necessary for rigidity. Two disadvantages prohibit the use of larger shafts. One is the small gain in critical speed with larger diameters. The other is that large-diameter shafts must be very carefully balanced to minimize vibration.

Vibration, of course, is the chief cause of shaft failure. Correcting for unbalance is difficult because if the shaft isn't balanced it isn't a rigid body.

If the truck is designed correctly, air damping can be used to cut down shaft vibration. Air damping can be used to make the shaft run safely even at its critical speed. Silicones and other lubricants inside the tube have failed to reduce vibration.

Most truck manufacturers minimize the danger of exceeding the critical speed by installing adequate gearing.

A single-piece shaft is economically and mechanically preferred to a multipiece shaft. Of course, if the distance between the transmission and axle is too great for a $4\frac{1}{2}$-in. tube to maintain its rigidity, a multipiece shaft is mandatory. Center bearing and alignment problems will then arise.

Rear Axle

The rear axle is the last element in the power train before energy is actually used to drive the truck. Among its functions, the axle must transmit the driving energy, carry the load, and help stop the truck.

If full load is maintained only part of the time, a 2-speed axle may be needed to get maximum performance. Also, a gearbox can be added anywhere between the engine and drive wheels.

Determine how much power is needed to haul the maximum load. A truck with excess power is better off with low axle reduction. With less reduction, engine speed is cut down and fuel economy is improved.

From the standpoint of durability, the rear axle should be designed for over-the-road requirements. The highway is the toughest proving ground for gears.

The Authorities

MEMBERS of the panel that elucidated the subject "Power Train Compatibility" were:

Panel leader:

J. F. Swift, International Harvester Co.

Secretary:

C. B. Rawson, Commercial Car Journal

Members:

F. E. Sandberg, Ford Motor Co.

R. E. Kaufman, Chevrolet Motor Division, GMC

A. F. Stamm, Chrysler Corp

R. R. Burkhalter, Dana Corp

C. V. Crockett, GMC Truck & Coach Division

Driver Controls

If the truck is destined for long cross-country hauls, the inside of the cab can be important from a safety standpoint. Road visibility should be unobstructed.

The driver must be alert and comfortable. The cab's design and colors should be pleasing to the eye. Adequate seats should be provided. A radio breaks the monotony of long trips.

The cab should be insulated from sound and heat. Air conditioning is standard equipment on some trucks operating in the Southwest.

Brake, gear shift, and horn levers, and dash panel switches should be within easy reach of the driver. For mountain driving extra brakes are needed.

The feel of the controls is very important to the driver. When he turns the steering wheel he should immediately feel the truck respond. The driver can become tired out and exasperated if he has to wind the steering wheel through three or four revolutions before the truck starts to turn. Brakes, clutch, gear shift, and accelerator should also respond quickly.

Make sure the parking brake is adequate to hold the gross vehicle weight. Auxiliary brakes may be necessary for steep hills.

Springs and shock absorbers should be adequate to carry the maximum load. Ride improvement will reduce wear and tear on the truck and the operator will save on maintenance bills. The number of his damaged cargos will be cut down. And most important of all, driver fatigue and accidents will lessen.

Henry M. Crane
1874-1956

HENRY M. CRANE, president of SAE in 1924, died on January 21, 1956, at the Roosevelt Hospital in New York after a long period of ill health.

Crane held a unique position as special consultant on engineering matters for General Motors during the last 34 years of his life.

In GM, he was the engineering equivalent of the high Cabinet official sometimes known as "Minister without Portfolio." Throughout the years, his penetrating mind and vast engineering knowledge contributed directly to the thinking and performance of scores of individual engineers in the company which he served.

He was generally known as "Uncle Henry," both by his GM and his SAE associates. . . . And his periodic visits to groups of working engineers continued to stir their minds and deter their complacency up to the year of his death.

In addition to his many contributions to automobile and automobile engine design, Crane also designed engines for inboard "Dixie" boats and sailing craft. He designed the engine for the Dixie II which won the first Harmsworth Trophy race held in the United States shortly after the turn of the century.

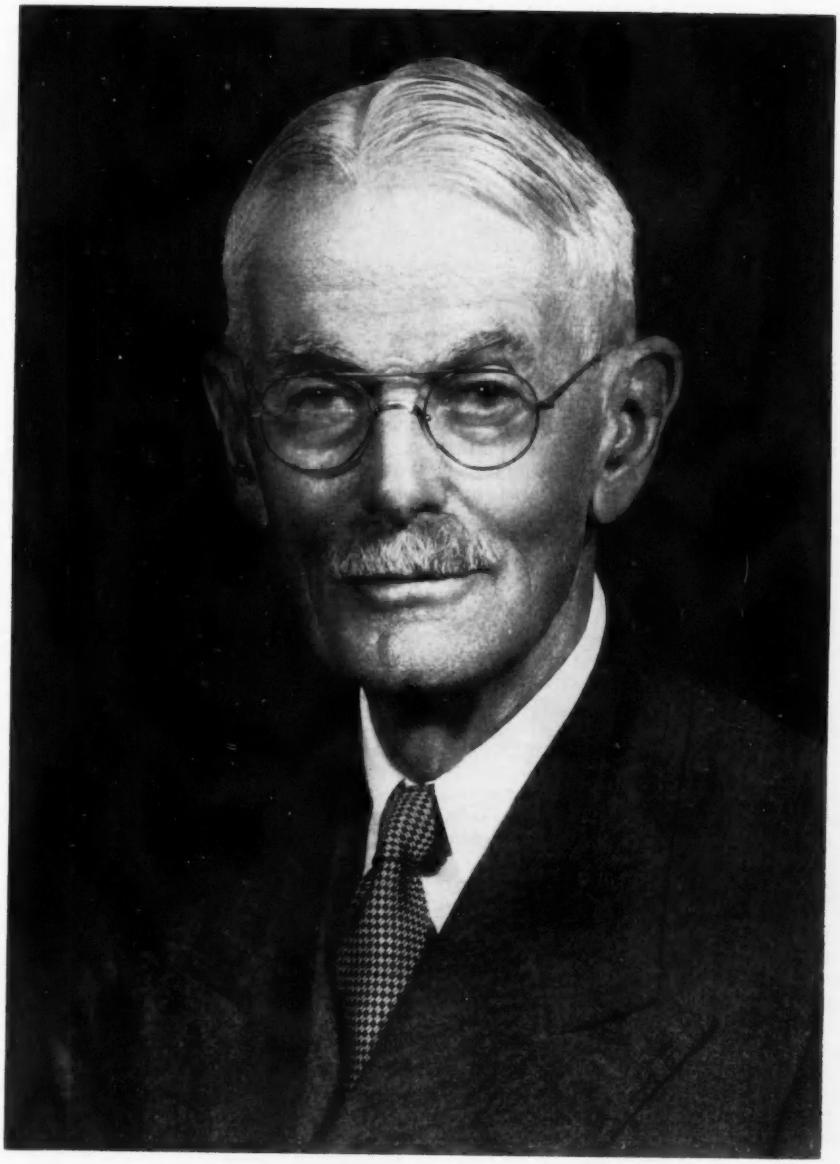
His interest in SAE began when he joined the Society in 1912 . . . and it never flagged through the later years when the intensity of his participation necessarily diminished. It was characteristic of his life-long attitude toward the Society that within the five years preceding his death he spoke twice before Society meetings and was the active chairman of a Metropolitan Section committee honoring 25- and 35-year members.

In the years of his greatest activity, he played an important part in the original Society work on matching of fuels to engines and engines to fuels; presented many authoritative technical papers before the Society; and contributed depth and zest to the discussion of technical papers at practically every national meeting.

Born in New York City, Crane went first to Phillips Exeter Academy; then on to Massachusetts Institute of Technology. There he took degrees in both mechanical and electrical engineering. He gained his first fame in the automotive world as the designer of the Crane-Simplex car, product of the Simplex Automobile Co. From 1916 to 1920 he was vice-president of the Wright-Martin Aircraft Co. . . . and in 1922 began his long affiliation with General Motors as an engineering consultant to the then-president Alfred P. Sloan, Jr.

Until nearly the age of 60 he was an excellent tennis player. In the days of SAE Summer Meeting tennis tournaments, he and the late Coker F. Clarkson were perennial winners of the doubles. Concentrating on golf in his later life, he became a consistent player in the 70's and low 80's.

Crane was a bachelor, lived for many years at the Weylin Hotel in New York. Plans to convert the Weylin to offices had caused him to move to the Waldorf-Astoria a week before his death.



Henry M. Crane
1874-1956

On almost every type of vehicle suspension . . .

Leveling Devices

USE of a constant leveling device on almost any type of commercial vehicle suspension permits springs to be made softer, thereby increasing riding comfort and reducing damage to the cargo, vehicle, and road. The floor level is automatically kept at a constant height, no matter how heavy the load so the vehicle can be designed with more payload space and still remain within the standing heights of commercial vehicles specified by law.

The type of leveling action varies with the type of suspension. In some types the height of the vehicle is held constant but the rate of the suspension is not changed. In other types, as the load is increased and the height is held constant, the rate of the suspension is increased in the same proportion as the load, so the frequency of the vehicle motion remains unchanged. In the third type, as the load is increased, the rate of the suspension increases more rapidly, so the frequency of the vehicle motion increases.

In the first type the springs can be softened only moderately; otherwise, at full load, rolling on corners becomes troublesome.

In the second type the action of the vehicle on the road is almost the same, loaded or empty, and the rolling on turns can be taken care of.

In the third type the stability of the vehicle fully loaded is actually improved, but there is danger of producing an intolerably hard ride at full load.

Leveling devices can be operated manually, as on the Mercedes passenger car, or automatically, as on GMC coaches.

Power for leveling is available from:

- electric motor and reduction gearing (Packard automobile)
- oil under pressure (Flxible bus, Citroen passenger car)
- air under pressure (GMC coach, large trailers with air suspension)

The electric motor controls leveling by a reversing switch which, after a reasonable pause for deliberation, raises or lowers the load as required.

Oil pressure leveling is controlled by two valves, which may be operated mechanically or electrically. When the mean standing height of the vehicle is detected to be low, one valve opens and allows oil pressure to raise it to correct height. When standing height is too high, the other valve bleeds oil from the suspension units back to the reservoir.

Air leveling is similar except the air is allowed to escape when released from the suspension units.

Theoretically, vehicle height can be adjusted so quickly that the ride of the vehicle can be flattened considerably. Thus nose diving when the brakes are applied or squatting during acceleration, can be prevented. Too, rolling can be resisted on corners and the vehicle can be made to "bank" on turns. However, less power will be consumed and the normal ride motions of the vehicle will usually not be interfered with if there is a delay action of 10 to 60 sec before the leveling device adjusts vehicle height.

One of the most important decisions to be made in designing a leveling device for a vehicle suspension system is how many of the four corners of the vehicle should be allowed to adjust themselves for height. Currently there are systems in which all four corners, or the front end and two rear corners, or both ends, or the rear end only are adjusted.

When all four corners adjust themselves there is likely to be difficulty when one wheel becomes higher than the others, as when standing on a curb. The mechanical brains of the four leveling units each try to compensate and are presented with an unsolvable problem. Two diagonally opposite corners think they are standing low and try to pump up, while the other two think they are standing high and try to let down. Since they are adjusting according to height only (not load) neither pair can win. Theoretically, unless the vehicle can bend diagonally it will end up with one pair carrying almost all the load. When the vehicle starts off again it has to do a major job of readjustment.

Permit Softer Rides

Maurice Olley, Chevrolet Motor Division, GMC

Based on paper "Report on Suspensions for Commercial Vehicles" presented at SAE Golden Anniversary National West Coast Meeting, Portland, Oregon, Aug. 15, 1955.

Whenever three or four points are adjusted, the vehicle tries to level itself with the road even when turning corners. So it is likely, for example, to come out of a left turn listing to the left. Whether this is objectionable or not depends on the type of vehicle and the speed of leveling and must be determined for each case. A great advantage is that such a vehicle stands level even with a lop-sided load.

Leveling Pneumatic Suspensions

Any form of pneumatic suspension requires some form of leveling, not only to balance the load changes and replace leakage, but also to compensate for atmospheric changes. Some systems use air, others use oil for leveling.

In large vehicles compressed air is already available so that direct inflation of the air bellows is convenient. In smaller vehicles, theoretically, there are advantages in using oil for leveling. Due to the increasing use of power steering, oil at several hundred psi is available at low cost.

One typical type of pneumatic suspension is the Firestone Air Spring (shown in Fig. 1). It looks like a nylon cord tire (with two layers of nylon fabric) that is rubber-coated inside and out. Ordinary springs decrease in frequency as the load increases and at light loads frequency is very fast. But with the air bellows the frequency is about the same at all loads, as shown in Fig. 2. Since freight vehicles often travel partly laden this feature is important.

Another type of pneumatic suspension is the General Air Spring. (A full description was published in SAE Journal, July 1954, page 40.) Basically it is similar to the Firestone bellows but has an elongated shape which fits readily into the space vacated by the conventional leaf spring. (See Fig. 3.)

The Citroen passenger car has another type of pneumatic-hydraulic suspension. As shown in Fig. 4, the "air" spring is actually a rubber ball in which nitrogen gas has been sealed under pressure. This is enclosed in a metal sphere which forms the upper

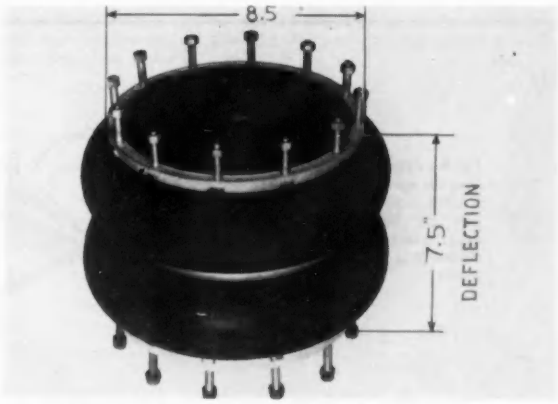


Fig. 1—Air spring (by Firestone) is made like a nylon cord tire, with two layers of nylon fabric, rubber coated inside and out.

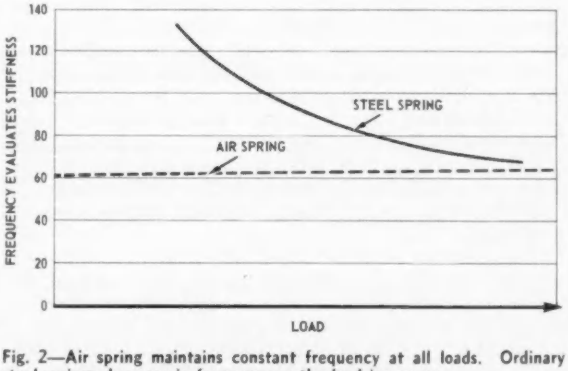


Fig. 2—Air spring maintains constant frequency at all loads. Ordinary steel springs decrease in frequency as the load increases.

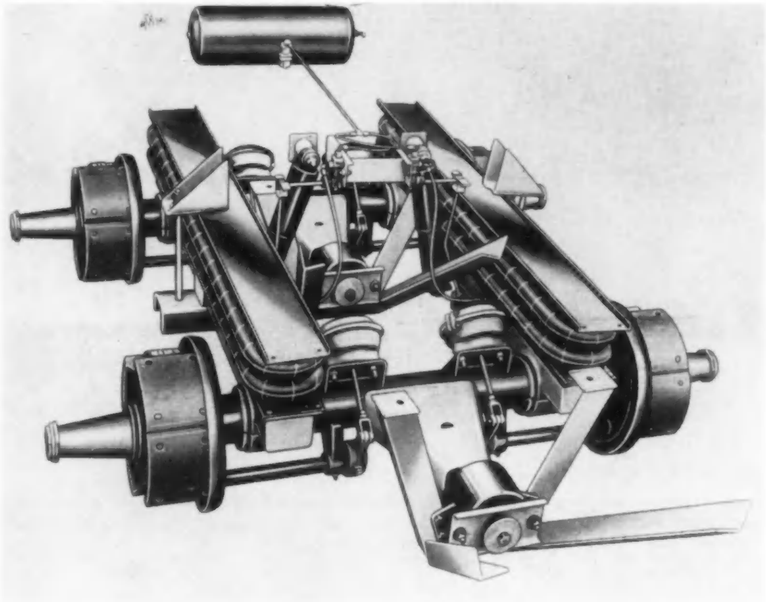
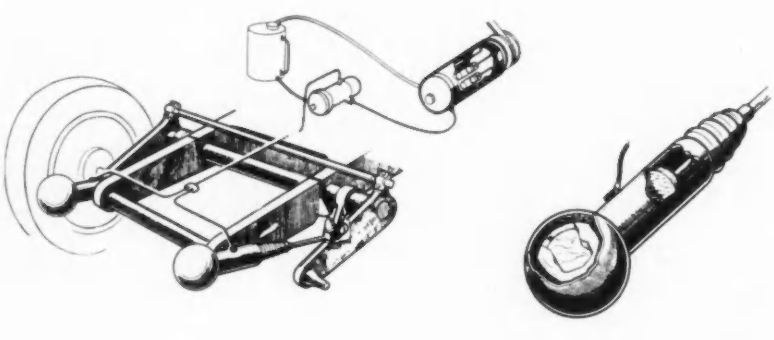


Fig. 3—General Tire air spring uses an elongated air bellows which fits into the space usually used by a leaf spring.

Fig. 4—Citroen passenger car uses air spring consisting of a rubber ball in which nitrogen gas has been sealed under pressure. This is enclosed in a metal sphere as shown.



end of what looks like a direct-acting shock absorber. Thus the spring and damper are in one compact unit. Automatic leveling is accomplished by pumping oil into the unit or releasing it. Power for this is supplied by a small high-speed engine-driven pump. The pressures are high, which implies that a great deal of energy can be stored in a small space. The size of the unit is comparable to an ordinary shock absorber. Since this air spring operates on a fixed weight of air and spring rate increases approximately as the square of the load, this system does not appear suitable for heavy vehicles because of the large increase in frequency and the small working stroke.

One method of leveling an air bellows suspension is shown in Fig. 5. (This system is described in detail in the **SAE** Journal of July 1954, page 41.) Inflation is automatically regulated to maintain a constant average standing height regardless of load. Valve operation is heavily damped by the pistons so that it responds only to basic changes in standing height and takes no notice of the more rapid vertical motions of the road wheels.

Leveling Rubber Suspensions

Rubber suspension has been used quite widely on commercial and military vehicles. Fig. 6 shows the Goodrich Torsilastic suspension and leveling device used in a 2-level intercity bus. Each suspension unit is a very large rubber bushing of which the inner or outer portion is held to the vehicle or axle while the other portion carries the suspension arms. (A complete description of this system is published in the July issue of **SAE** Journal, page 20.)

In addition to adjusting vehicle height due to load changes, automatic leveling compensates for changes in standing height due to ambient temperature changes and initial creep of the rubber in shear which suspends the vehicle.

The vehicle is leveled automatically at each of

the four corners by admitting oil at 1500 psi to hydraulic cylinders. A pump and motor unit is similar to that used in a lift truck. It takes 30 sec to level from an empty to a fully loaded vehicle.

This suspension features a usable vertical stroke of 12 in. at each wheel.

On this intercity coach the dynamic spring rates are about 400 lb per in. (front) and 700 lb per in. (rear). This gives ride frequencies as follows:

Front: Empty—74 cpm	Loaded 62 cpm
Rear: Empty—69 cpm	Loaded 60 cpm

The variation of ride frequency is not too much between empty and fully loaded. Even this variation can be reduced by taking advantage of the fact that the dynamic rate of these suspension bushings can be made to increase as the stress on the rubber is increased. Thus an approach to a constant frequency at all loads is available with a rubber suspension.

Leveling Liquid Springs

Liquid springs are based on the fact that liquids *are* compressible. Some suitable new fluids are compressible by as much as 12% of their volume under 20,000 psi pressure. Such a pressure will carry a 10,000 lb load on the end of a rod 11/16 in. in diameter.

Leveling liquid suspensions has not yet been at-

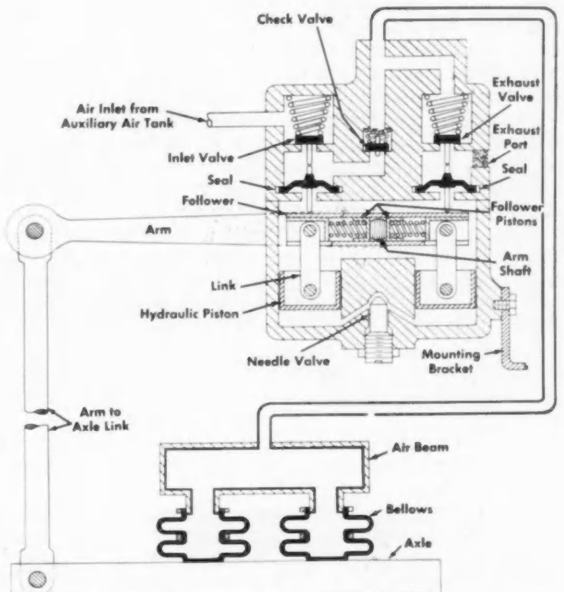
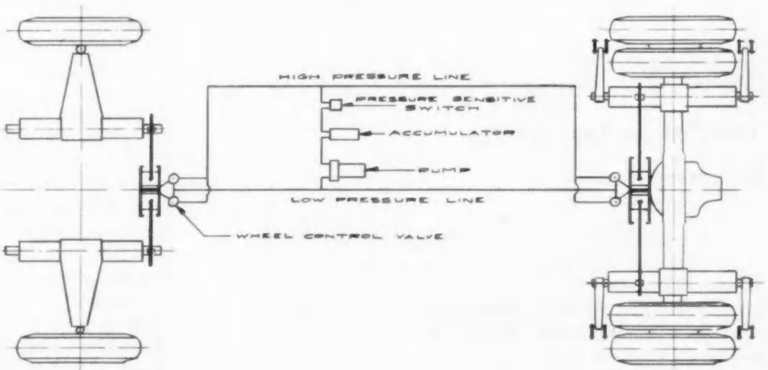


Fig. 5—GMC coaches use the above method of leveling an air bellows suspension automatically. Constant average standing height is maintained regardless of load.

Fig. 6—Schematic of the constant level device and Torsilastic suspension used on an inter-city coach. Essentially suspension is a large rubber bushing, one part of which is attached to the vehicle or axle, while the other portion carries the suspension arms.



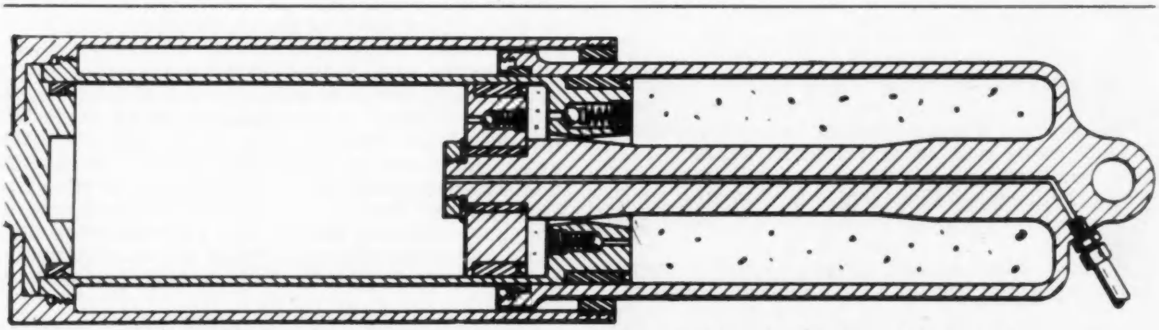


Fig. 7—Liquid suspension spring (for trucks) uses differential areas and large volume displacement for damping.

tempted. Presumably, at least, a diesel injection pump will be necessary; however the volume of fluid required for leveling will be extremely small. It doesn't appear that the rate of a liquid suspension will adjust itself to the load in such a way as to give constant frequency.

If a direct acting shock absorber is filled entirely with fluid, the displacement of oil by the piston rod, as the device is compressed, acts as a spring, while the oil which flows through the valves in the piston supplies the necessary damping action.

Very high pressures are built up within the cylinder so each container must have thick walls, free from defects and have packing glands designed to withstand high pressures without leaking. These difficulties are not insuperable. In some applications the enormous energy storage capacity of the liquid spring is so important as to make it almost the only device which can be used in the space available.

Fig. 7 is a view of a truck suspension liquid spring using differential areas and large volume displacement for damping.

It may be possible to obtain considerable damping action by dissipating energy in the liquid itself. Certain liquids are polymorphic; that is, when heavily compressed at certain critical pressures and temperatures, they will contract rather suddenly and change from a liquid to a solid or grease. This sudden contraction releases heat and the reconversion to a liquid occurs only gradually as heat is recovered. Consequently, such a liquid worked at its point of polymorphic change may supply in itself a powerful damping action.

Discussion

The Case for Leaf Springs

N. E. Hendrickson,
Consulting Engineer

The leaf spring is the oldest form of automotive suspension. Theoretically it is a beam of uniform stress; that is, the leaves are so proportioned that the stress is the same throughout the length of the spring. Leaf springs of motor coaches have been much improved during the past dozen years. Present day truck springs, with rare exceptions, are still too short, too narrow, and too stiff. The truck driver must drive a vehicle with spring frequencies between 100 and 150 cps, because the springs on the truck have blunt-end leaves, causing the leaf-end pressure to be concentrated on so small an area that wear and "digging in" occur after a few hundred miles of operation. Even a reasonable static deflection may be sadly marred by excessive "starting" friction, resulting in a *momentary* spring "rate" many times the normal value. This high starting friction will be particularly detrimental to the riding qualities.

A new concept of leaf springs for heavy-duty vehicles is needed based on the following factors:

1. Dimensions should be generous for ample flexibility. Leaf points should be roll-tapered for maximum responsiveness to road shocks.

2. Waste of effective material at the axle seat should be kept to a minimum.

3. Full consideration should be given to the shackle angle possibilities for giving variable rate characteristics under changing loads. (See SAE Manual on Design and Application of Leaf Springs.)

4. The finest possible steels, with minimum decarb and surface irregularities, should be chosen and properly heat-treated so that high-working stresses can be safely allowed.

5. The tension surfaces should be shot-peened to increase the life.

Such springing will not only be economical in spring cost per mile, but it will serve the far more important function of insulating the vehicle effectively from the shocks of the road.

The Case for Torsion Bars

H. O. Fuchs,
Metal Improvement Co.

A torsion bar can absorb more energy per pound than any other spring. This is due to its efficient uniformly-stressed shape, to the fact that springs stressed in torsion or shear can be pre-set more effectively than springs stressed in bending, and to the fact that the entire stressed surface is readily accessible for stress-proofing operations, such as removal of defects and shot peening.

The torsion bar is particularly adapted to use with leveling devices because it is relatively easy to rotate the anchor. An inexpensive type of torsion bar, consisting of a flat spring similar in shape to a leaf of a leaf spring, is currently being used on foreign automobiles. This bar requires no special ends. It is merely cut off and slipped into a V-shaped groove. It is very efficient in storing energy per unit cost. Because there are no inactive ends and because with pre-setting (limit design) the stress distribution is more uniform, its weight is less than a coil spring of equal capacity and equal stress. The flat torsion bar requires more width than the round bar, but less length, especially if the ratio of width to thickness is higher than 5. Length can be further reduced by using bundles of bars, as in the Volkswagen front suspension.

With flat torsion bars there is the possibility of achieving variable rate. An S-shaped torque-twist or load-deflection curve is obtained if the spring has initial twist; the minimum rate occurs when the spring is flat. This feature is particularly interesting in connection with leveling devices because these preclude the use of the changing lever angle for rate variation. Variable rate can be achieved with any spring by use of the correct geometry in shackle angles, length and position of lever arm, or by auxiliary springs. However, these methods depend on a change in standing height to change the rate. The flat torsion bar depends only on the windup angle, regardless of the standing height, which can be held constant.

For complete paper (in multilith form) on which this abridgment is based, write SAE Special Publications. Price: 35¢ to members, 60¢ to nonmembers.

What We Know Today About Diesel Deposits

CRC report analyzes modern researches on engines, fuel, and operating factors that induce deposits.

BEFORE a researcher undertakes an investigation, he studies the findings of others who have worked in the same area so as to avoid duplication and save time. A CRC group has gone a long way toward doing this job for researchers in the diesel engine field by recently issuing a report on deposits. It's CRC-288, "A Survey of Available Information on the Deposit-Forming Characteristics of Diesel Fuels and Engines."

An Analysis Panel, under the Diesel Fuels Division of the Coordinating Fuel and Equipment Research Committee, reviewed and pulled together all readily available information, both published and unpublished, relating to deposit-forming characteristics of diesel fuels and engines. It has made its analysis of deposit-formation factors in terms of: (1) engine design, (2) engine operating conditions, and (3) fuel characteristics. Of course, no factor in design, operation, or fuel is completely independent of the others.

1. Influence of Engine Design on Deposits

There is little available information on the influence of specific engine design details on deposit formation. But there are general considerations from which the anticipated influences of design may be predicted.

Engines of different design generally will respond in the same direction to changes in fuel. However, the degree of response varies widely for different designs. Some investigators conclude that deposit formation and exhaust smoke are affected more by engine design variables than by fuel variables. One study of design, operation, and fuel variables led to the conclusion that design variables were the most important in controlling deposit formation from distillate fuels, followed by operational and fuel variables in that order.

Several references consider the conditions conducive to deposit formation. These are conditions which hinder complete combustion of the fuel. Engine design is important in establishing the limits of these conditions. The more important design features are:

1. Efficiency of Fuel Injection: Overpenetration leads to incomplete combustion because of the condensation of fuel on combustion-zone walls, or of incomplete mixing of fuel and air.
2. Prevailing Temperature of Combustion-Zone Walls: Low temperatures promote condensation of unburned or partly burned fuel.
3. Surface-to-Volume Ratio of Combustion Zone: A high surface-to-volume ratio increases the possibility of impingement. Large bore engines are likely to be least sensitive to fuel variations.
4. Engine Speed: High-speed engines are likely to be more sensitive to changes affecting efficient breathing and hence complete combustion of the fuel.
5. Compression Ratio: Higher compression ratios reduce the chances of misfiring. This makes the engine less sensitive to fuel ignition quality.

No engine design factor can be considered independently of the fuel for which the engine was designed. Design factors have a major influence on the engine's sensitivity to changes in fuel and operating conditions.

CONTINUED ON NEXT PAGE

2. Influence of Operating Condition on Deposits

Two types of operating conditions are particularly conducive to deposit formation. They are:

1. High-temperature, high-load operation bordering on overload, and
2. Low-temperature idle or low-load operation.

The high-load operation results in over-richness and causes soot and black exhaust smoke. The low-load, low-temperature operation promotes the formation of varnish, lacquer, polymerized carbonaceous deposits, and acrid blue exhaust smoke. Low-load operation generally is most severe in causing the formation of extensive deposits harmful to engine performance, and represents the type of operation with which the CRC group was most concerned in its analysis. Within certain limits of operating conditions, the lower-load operation may not produce more deposits.

Low-load conditions are critical because they are conducive to incomplete combustion of the fuel. Low effective cylinder wall temperatures promote formation of partially oxidized, reactive compounds from the fuel. These condense on the colder engine surfaces and react to form resinous varnish and lacquer, and result in oil-soluble carbonaceous deposits.

Misfiring or poor mixing brings unburned and partially oxidized fuel in the exhaust. They create the acrid odor and blue smoke which are symptomatic of these operating conditions.

Formation of low-load, low-temperature deposits can be influenced markedly by ambient temperatures or by high altitudes. Fuels which may perform satisfactorily at low load in ordinary weather conditions may cause severe deposits when ambient temperatures are very low, or when the engine is operated at altitudes which alter the air-fuel ratio.

3. Influence of Fuel Properties on Deposits

Effects of the following fuel properties on deposit formation have been considered: (1) ignition quality—cetane number; (2) distillation temperature—volatility; (3) viscosity; (4) gravity; (5) carbon residue; (6) composition—hydrocarbon types; (7) sulfur content; (8) nitrogen content; and (9) fuel age and deterioration in storage.

It has been impossible for investigators to isolate and study any one fuel characteristic completely independently of all others. A considerable portion of the investigations were done before the significance of sulfur content and chemical composition were fully recognized.

Apart from sulfur content, and perhaps composition, combustion chamber design will determine the relative importance of the physical characteristics of the fuel. Therefore, the importance of various fuel properties cannot be generalized without consideration of the engine in which the fuel is to be used.

An increase in cetane number (or diesel index) will decrease deposit formation and reduce smoke, which is considered a corollary of deposit formation. The influence of cetane number is not independent of other properties. So it is not a controlling variable.

Cetane number is not considered as important as sulfur content. A low cetane number fuel which performed adequately at normal ambient temperatures was unsatisfactory at very low temperature. A substantial increase in cetane number alleviated, but did not eliminate, the deposits. A relationship between cetane number and deposit formation was observed for otherwise similar fuels, but did not hold for widely different fuels.

A decrease in smoke with increasing cetane number was observed for fuels of 400 to 500 F end point, but not for 600 to 700 F end point. Similarly, lowering the cetane number from 52 to 34 in fuels of 630 to 670 F end point had little influence on deposits.

In another investigation, a fuel of 33 cetane number gave more deposits than would be expected from its distillation range (640 F end point). In one investigation, a fair relationship was found between cetane number and deposits, which held for straight-run and cracked fuels. A low cetane number, high-deposit fuel plus two different cetane number improvers showed an improvement in deposits in close agreement with the improvement in cetane number.

Ignition quality is important in determining the range of conditions under which the engine will operate without misfiring. But it alone is not a guarantee against deposit formation.

The temperatures necessary to volatilize and distill a fuel are considered the most important criterion of volatility, rather than vapor pressure or the breadth of the distillation range. An increase in average distillation temperature will increase deposit formation. The presence of even small amounts of residual fuels blended with distillate fuels generally increases deposits markedly, although some engines may be insensitive to presence of residuals.

The 50% point of the ASTM distillation has been used most often as an index of average distillation temperature. But in one investigation, a factor considered better was calculated from the sum of the 20% and 80% points, divided by two. Limited observations suggest that light ends have no significant effect on deposits. However, the 90% point and the end points are important. In one investigation, volatility appeared critical only if the 90% point were over 650 F.

In one study, the effects of volatility were found to be contradictory. They were overshadowed by ignition quality. In another, increased paraffinicity had a greater influence on deposits than volatility. The relationships among properties are apt to be complex. That's because an increase in average distillation temperature is difficult to dissociate from an increase in viscosity, and paraffinicity and ignition quality also are closely related.

An increase in viscosity generally will result in

increased deposits. Viscosity, again, is not an independent variable. Since viscosity is important in determining the injection characteristics of the fuel, it will influence the efficiency of mixing and amount of impingence. Both of these contribute to the liquid condensate which leads to deposits.

Viscosity alone is not a sufficient index of deposit-forming tendencies. Viscous polybutenes were found to be low-deposit fuels in one investigation. In another, a relationship between viscosity and deposits was apparent only when the fuels were similar in other respects.

An increase in API gravity (a decrease in specific gravity) is related to a decrease in both deposit-forming tendencies and exhaust smoke. In one investigation, gravity was found to be a more reliable index of deposit-forming tendencies than cetane number, volatility, viscosity, and carbon residue. This was attributed to the fact that gravity reflects both paraffinicity and volatility, which in turn determine ignition quality and viscosity.

For distillate fuels, carbon residue is not a reliable indication of deposit-forming tendencies. In one investigation, a relationship between Conradson carbon and deposits was found, but there were exceptions. Conradson carbon was found to be a valid index of nozzle coking where residual fuels were involved. But in general, carbon residue is not a sufficiently sensitive test to be applied to distillate fuels.

Among the hydrocarbon types investigated were aromatics. Increased aromaticity seems to increase the deposit-forming tendencies of fuels under low load, low-temperature conditions. In one case, aromaticity was one of two single properties (along with gravity) which successfully placed a number of varied fuels in the proper order with respect to deposit formation.

Increased aromaticity was found to increase smoke under high load conditions in one investigation, but not to increase port deposits as did sulfur in another research. The evidence on the influence of olefinic unsaturation on deposits is fragmentary and contradictory.

Sulfur content is considered one of the most important factors governing deposit formation in both low-load, low-temperature and high-load, high-temperature operation.

One investigating group found that increasing sulfur content from 0.2% to 1% increased engine fouling by 40 to 80%. Sulfur content was considered more important than ignition quality, viscosity, or volatility. In two other investigations, increases in sulfur content over 0.5% caused increased engine deposits. And in a third investigation, a straight-run fuel containing 0.6% sulfur increased port deposits; while a lower sulfur cracked fuel (0.09%) performed as well as a straight-run fuel of similar low sulfur content.

The influence of sulfur on wear was realized earlier than its influence on deposit formation. Oils containing detergent-dispersant additives were found to reduce the effect of sulfur on engine wear. Similarly these oils have reduced the effect of sulfur on deposits. However, additive oils may not compensate completely for the harmful effects of sulfur in either wear or deposits.

Sulfur content is one of the few fuel properties which may affect deposit formation by some chemical means other than a direct influence on the efficiency of combustion. Sulfur may provide acid catalysis of the condensation reactions, leading to lacquer, varnish, and carbonaceous deposits.

The influence of nitrogen content has not been investigated extensively. The addition of nitrogen compounds known to have a harmful effect on fuel storage stability had no significant influence on engine deposits in one investigation.

Diesel fuels are subject to the formation of both soluble and insoluble gum during storage . . . but to a degree depending on their stability characteristics. The insoluble gum is settled out or removed by filters, and should not be a factor in combustion chamber deposits. The soluble gum may have some influence on deposits. This possibility has not been formally investigated. Two reports suggest that soluble gum caused injector malfunctioning and subsequent severe carbon formation in stationary engines at the powerplants in Whitehorse and Fort Churchill, Canada.

(The report on which this article is based, CRC-288, is available from SAE Special Publications Department. Price: $5.00 to members, $10.00 to nonmembers. The report contains 124 pages, has abstracts of 33 published reports and papers, a survey of information from CRC files on diesel engine deposits, and other related material previously unpublished.)

Scope of Survey

The study discussed in this article was confined largely to data on small, high-speed automotive type diesel engines. In only a few cases was information used concerning intermediate speed and size diesels of the locomotive type. Large, slow-speed diesels used in stationary and marine service were not considered.

The deposits investigated are those resulting from a combustion of fuel. They are mainly organic in origin, and include lacquer, varnish, and carbonaceous deposits on the injector nozzle, combustion chamber surfaces, exhaust valves, ports, passages, and in the upper cylinder and crankcase when fuel is responsible.

They do not include deposits due to fuel instability before injection. Exhaust smoke is included only as it is symptomatic of conditions conducive to formation of deposits in the engine.

The report deals chiefly with performance of engines operated on distillate fuels rather than residuals.

Light Metals . . .

. . . are playing an ever bigger role in automotive engineering. Their cost cutting potential lies in utilization of their inherent properties, beginning with the original part design.

Based on paper by **M. F. Garwood and F. H. Mason,** Chrysler Corp.

LIGHT metals are readily adapted to the concept of high-production, low-cost automation. But in our experience there are only three methods of fabrication which now satisfy all the requirements of our industry. These methods are casting, both die and permanent mold; hot extrusion; and cold extrusion, or cold forging.

Light alloys can be cast in automatic equipment at a very high rate of speed and to very close tolerances, and the casting can be made to embody a high degree of intricacy and coring. Cold impact extrusions are replacing more expensive ferrous stampings, forgings, and tubing. The process is inexpensive, simple and can be incorporated easily in any automatic procedure. Hot extrusion also produces low-cost parts. Tool costs are insignificant and a large number of dies can be used on a single piece of equipment with minimum tool cost.

These metals can be machined at speeds far in excess of present production machine tool capacity. Actually, there is no known limit for the upper range of machine speed which may be used for aluminum and magnesium. And when the speed is increased, the finish improves.

The magnitude of cost differential contributed by material, fabrication process, and manufacturing operations is shown comparatively for aluminum and three other common metals in Fig. 1. This comparison was compiled from cost of actual parts and in each instance the same or similar parts were compared directly.

To get the most for the money, the best practice must be used in all operations. By definition, best practice means to use a fabrication procedure which takes advantage of the inherent properties peculiar to light metals. These properties for aluminum are:

Density	2.7 g per cc
Crystal form	Face centered cubic
Heat content	22.6 cal per Kg (212 F)
Melting point	1150–1200 F
Thermal Conductivity	0.52 (cal/sec/sq cm thickness)

Low density is reflected in lower cost for fabrication equipment and lower maintenance. The ductile crystal form results in desirable cold-forming characteristics. Low heat content means less heat put into a casting, permitting increased operating speed. Low melting point means lower operating temperature for all types of casting methods and results in longer equipment life and reduced costs. High-thermal conductivity is reflected in more efficient use of input heat for all pertinent fabrication operations.

Insofar as possible the best practice should be incorporated in the original design.

Experience with light metals tells us that only one basic type of aluminum alloy (8% silicon and 3% copper) is necessary for castings, and that all heat-treatment can be deleted for most casting applications. We have had little difficulty in designing for the low modulus and low ductility of the cast light alloys.

Corrosion studies reveal that it is unnecessary to maintain protective coatings for functional aluminum parts under any normal automotive service. Further, no special alloys or low copper types of aluminum alloys are required for parts in contact with engine coolants. The corrosion resistance of cast magnesium also is adequate without special protection for service exposure such as that associated with clutch housings.

Wear problems are sometimes encountered. Our experience has shown aluminum to be capable of satisfactory overall service if design provides proper conditions such as a hard surface for the part in contact with the soft aluminum. A break-in coating like tin plate is beneficial for some conditions. The hard anodic coating often used on aluminum to give wear resistance is usually unnecessary, but where high load or rough surfaces present the possibility of brittle break-up of the coating, the result will be severe wear or seizure from abrasive action. Under these conditions the anodic coating is actually harmful.

Magnesium, a very good bearing material, presents a greater wear problem. Greater sensitivity to load or lubricating film failure and to surface roughness requires, in general, that very good protection be provided. Generally speaking, with the exception of exposure to some conditions of corrosive media and wear, magnesium alloys can be used virtually interchangeably with aluminum. Some properties, such as machineability and weight, make it much more attractive. (Paper "Automotive Engineering Applications of Light Metals" was presented at SAE Detroit Section Meeting, Nov. 7, 1955. It is available in full from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

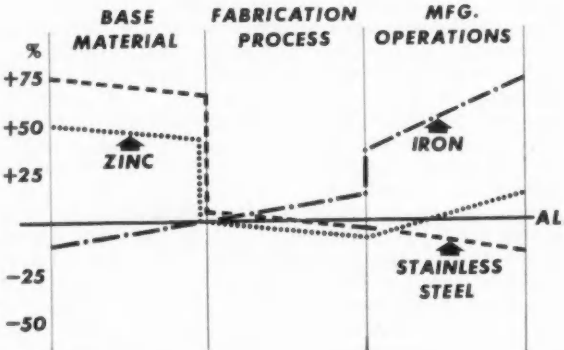


Fig. 1—Cost comparisons between aluminum and three competing materials put the former in a very favorable light.

Aircraft Noise Can Be Measured . . .

. . and its effect on human activities determined

*Karl D. Swartzel and Murray Kamrass

Consultant — Industrial Division, Cornell Aeronautical Laboratories, Inc.

* Now with Lockheed Aircraft Corp., Missile Systems Div.

Based on paper "Evaluation of the Noise Field Around Jet-Powered Aircraft" presented at SAE Golden Anniversary Aeronautic Meeting, New York, April 19, 1955.

HOW severely aircraft noise disturbs human activity depends on the sound's characteristics and the human being. The use of "hemispheric domes" and "isosilic surfaces" provide effective graphical means of studying aircraft noise effects.

Noise Characteristics

The first step in noise analysis is to establish the characteristics of the actual sound radiated from the airplane under study. For example, the noise field created by a B-47 airplane has been studied by measuring the output of one of its six J-47 engines. A conversion factor of 8 db was applied to the single engine data to simulate the noise field created by all six engines.

The measurements were made on the ground, under controlled conditions. The difference in sound level radiated with the engine in flight and as measured on the ground is assumed to be small.

Attenuation due to ground losses and turbulent effects were present during the ground observations. These attenuation factors tend to cancel some of the ground reinforcing effect. Therefore, no correction for ground effects were made to the measurement data.

It is not known how the directivity pattern is modified over that of one engine when several are operated in close proximity. Because of broadness of the directivity over the significant range, the effect is not expected to be important. No allowance was made for this effect.

Fig. 1 shows the noise level at a distance of 100 ft for the standard octave bands and at various azimuth angles from dead ahead (0 deg). The assumption was made that the sound pattern is symmetrical about the longitudinal axis of the airplane in flight. This has not been experimentally established, but it is a reasonable assumption that at some distance from the airplane the pattern is not greatly affected by the airframe geometry or the lack of airflow symmetry around the tail pipes of the engine.

Attenuation Factors

Starting with the noise characteristics near the airplane, it is next necessary to determine the sound

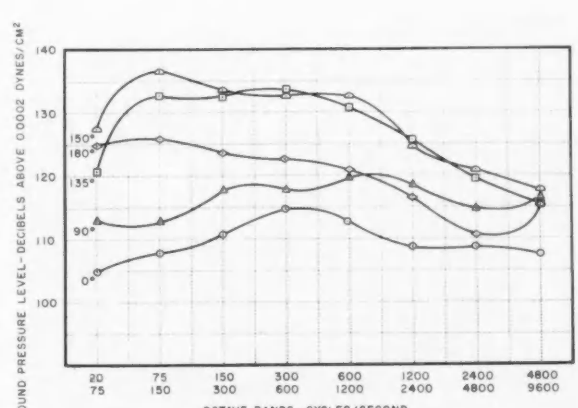


Fig. 1—The sound pressure levels 100 ft from the six engine B-47 airplane. The engines are operating at 7850 rpm. Various azimuths are indicated.

intensity at greater distances. Attenuation factors which influence intensity include:

Inverse Square Law: The energy per unit area in a wave radiating spherically in free, non-dissipative space attenuates in proportion to the square of the distance from the source or spherical center. If the distance from the source is doubled, the intensity is reduced by a factor of four. On the logarithmic scale, doubling the distance results in a decrease of about 6 db.

Air Damping: When sound waves are transmitted through a gaseous medium, there is a loss of sound energy through direct conversion to heat. In dry air this effect is small. When small quantities of water vapor are present the effect may be significant, particularly at the higher frequencies. For our computations a humidity value of 40% was chosen as typical.

Turbulence: The atmosphere is normally somewhat turbulent due to wind and convection forces. At low altitude attenuation due to turbulence is generally higher than that due to humidity. As the wind velocity increases, the attenuation becomes greater. A conservative allowance for stable attenuation due to turbulence was included in our calculations.

Wind: The wind has several effects on the propagation of sound. It can be a factor in turbulence near the earth. Or layers of wind can change the path of a sound wave and, thereby, the intensity of sound reaching a given point. In the earth's atmosphere a wind gradient is quite common. A positive gradient (increasing with altitude) refracts the sound upward on the upwind side of the source and downward on the downwind side.

These gradients may cause sound "skipping," a phenomenon causing sounds inaudible at short distances from the source to be heard at greater distances.

Temperature: The velocity of propagation of sound in air increases with temperature. If the temperature increases with altitude, the path of sound travel is refracted downward. The opposite effect occurs with the more usual negative temperature gradient. Temperature and wind gradients can interact to reinforce or nullify each other. Path anomalies resulting from temperature gradients have been ignored in our calculations because of their variability and because they are favorable to sound reduction.

Ground Attenuation: Sound is attenuated as it passes surface irregularities such as vegetation. Attenuation of 5 or 10 db in a distance of 1000 ft is possible. For a source at an altitude where the path of the sound wave has little contact with the earth's surface, ground attenuation is not important.

Terrain is not always a good absorber. Water reflects most of the sound which strikes it. Hard, bare, or rocky ground may reflect much of the incident sound energy. So, it is possible for the sound level to be increased by terrain. However, flat terrain accentuates the sound level by less than 3 db. Sound focusing occurs in certain types of curved terrain but such cases are small in extent and extremely rare. Because of their limited significance and their variable aspects, neither ground attenuation or focussing effects have been considered in our calculations.

Effect of Walls: Our calculations pertain to an unshielded point on the ground. Noise levels are 5 to 20 db lower inside buildings. The lower value would apply where windows were wide open; the upper value might be typical where all openings were tightly closed. Other factors which enter into wall attenuation are the type of structure, the relative orientation of the sound source, and the frequency spectrum of the sound.

Of the seven factors contributing to the attenuation of sound, only the distance effects associated with the inverse square law, the turbulence effect, and the air damping factor have been considered in the example of this paper, since they are of major importance. The effect of inverse square attenuation is plotted in Fig. 2, together with the air damping effects at various frequencies.

Sound Levels

Having determined the sound characteristics at 100 ft and the energy losses in terms of distance, we

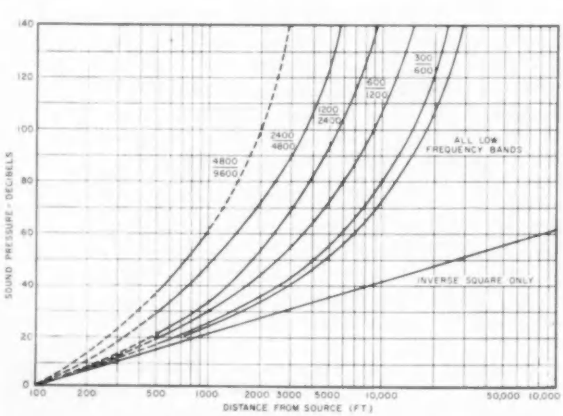


Fig. 2—The attenuation of sound in calm air of 40% relative humidity. The curves are octave frequency bands as indicated and were resolved by considering the distance effects associated with the inverse square law, the turbulence effect, and the air damping factor.

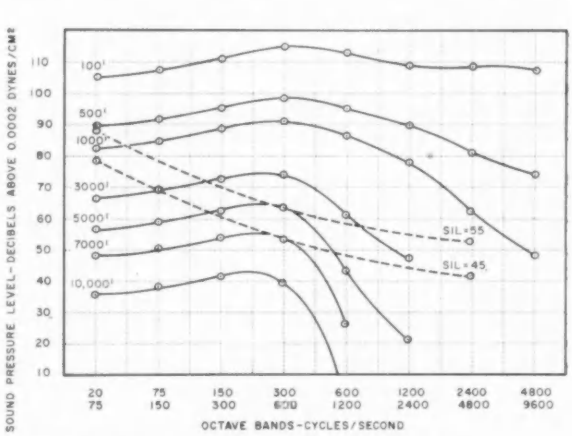


Fig. 3—The sound pressure levels of a B-47 airplane to distances of 10,000 ft from the source. This plot is for an azimuth of 0 deg. Note the more rapid loss of acoustical energy at the higher frequencies than at the low.

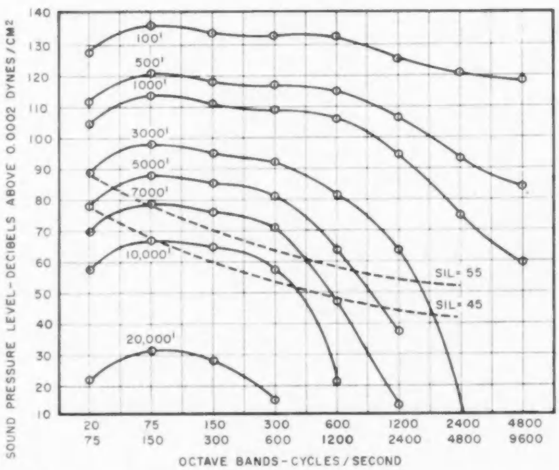


Fig. 4—The sound pressure levels of a B-47 airplane to distances of 10,000 ft from the source. This plot is for an azimuth of 150 deg. This angle is near the lobe of maximum energy.

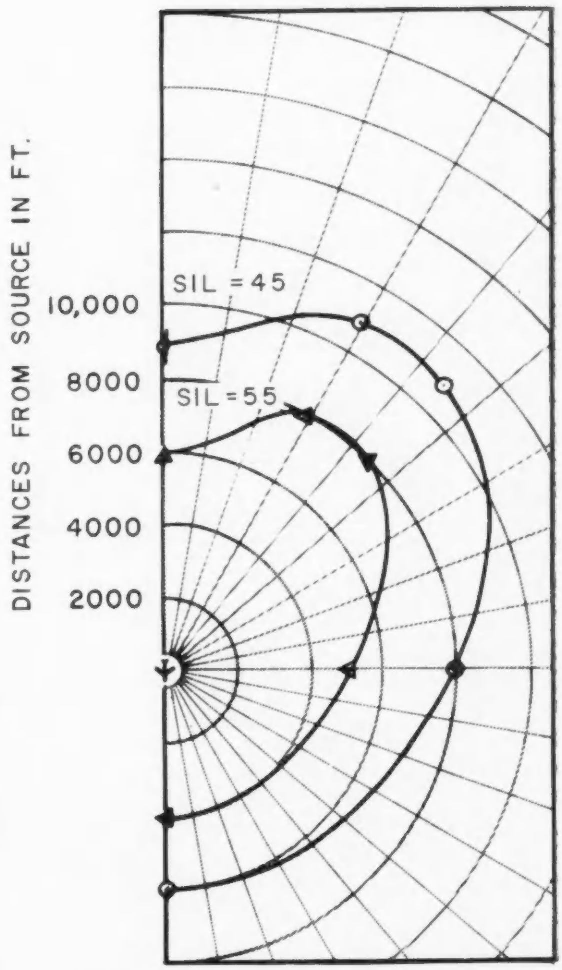


Fig. 5—The isosilic envelopes around a B-47 airplane.

can now describe the actual spatial patterns of sound levels at various directions and distances from the aircraft.

Fig. 3 is a plot of sound level versus frequency bands for distances out to 10,000 ft, when the aircraft is approaching at 0 deg. Note the more rapid loss of acoustical energy at the higher frequencies than at the low.

Fig. 4 is a similar curve for an angle of 150 deg. This angle is near the lobe of maximum acoustical energy. By using Fig. 3, Fig. 4, and similar curves plotted for other azimuths, we determined the distance at which less than two octave band levels exceeded the critical speech interference level, SIL 45, explained later.

Plotting these distances as a function of azimuth results in a cardioid shaped speech interference envelope or "isosil" contour representing that surrounding the airplane. Fig. 5 is a picture of such a plot.

Directivity effects are of considerable importance. Imagine the shape of a surface of equal sound level surrounding an aircraft in flight. If the radiation were non-directional, this surface would be a sphere with the aircraft at the center. But since directivity is significant, the equi-intensity surface for a jet aircraft would look something like the artist's conception in Fig. 6.

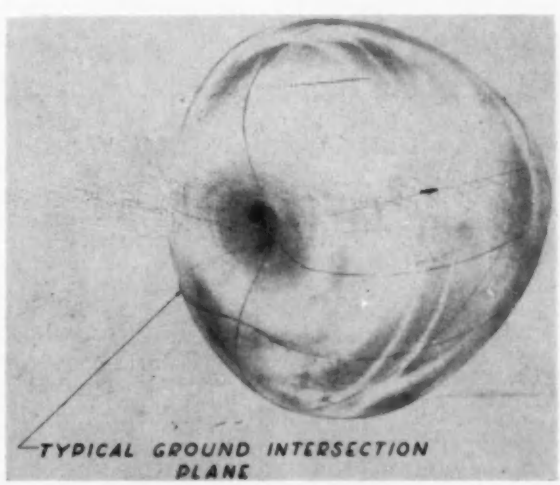


Fig. 6—Equal Speech Interference Surface surrounding a B-47 aircraft. Notice the lobes of intense sound astern of the aircraft and the typical cone of moderate silence observed dead aft of a jet engine in operation.

Human Tolerance Criteria

A difficult problem in the evaluation of aircraft noise is the correlation of measured sound energy, at various frequencies, with public disturbance and interference with human activities. Two interrelated loudness units, sones and phons, have found wide usage, but have limitations associated with human variables such as fatigue and prejudices. Generally, annoyance is directly related to loudness. However, loudness is not the only objectionable characteristic of noise and, therefore, other criteria are significant.

Criteria for determining what noise levels cause annoyance to people are presently being developed

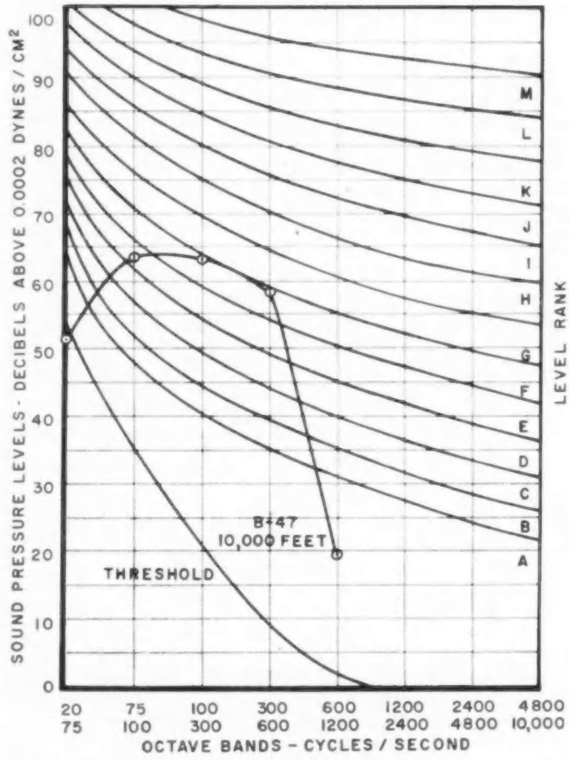


Fig. 7—A chart for determining noise level rank. Used in conjunction with Fig. 8, community response to noise can be estimated.

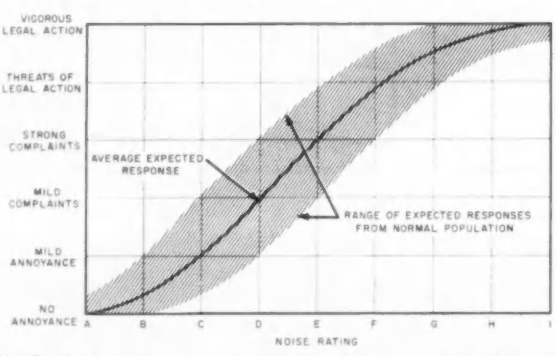


Fig. 8—Community response chart. This chart is used in conjunction with Fig. 7 to establish probable community response to noise.

on a statistical basis. It is not possible at present to rate annoyance quantitatively with accuracy and consistency. It is possible, however, to collect statistics from which the probable response of a community to a noise can be evaluated.

This response can be scaled through a range which includes no annoyance, mild annoyance, mild complaints, strong complaints, threats of legal action, and actual legal action. As shown in Fig. 7, a noise rating curve is chosen by letter to correspond to community reaction.

Choice is based upon such factors as type of noise, duration and frequency of occurrence, time of day, type of neighborhood, and previous noise exposure of the neighborhood. A considerable background of experience is helpful. Once the choice has been made, we can find the community response which can be expected to result from the noise by applying the curve of Fig. 8.

As an example of the use of these data, consider the maximum noise created by a B-47 airplane 10,000 ft from a suburban community with little noise exposure history. These data are plotted superimposed on the curves in Fig. 7. It can be seen that the noise extends into noise rank F. The figure applies to more or less continuous noise exposure.

Assuming one to ten exposures per hour rather than steady noise, the level rank can be downgraded to about D. Entering Fig. 8 at D, community reaction falls between mild annoyance and strong complaints with the average at mild complaints.

Beranek at MIT has proposed another method of noise evaluation based on the interference that noise has on the understandability of spoken words. While the formulation of Beranek's criteria is not yet complete, great progress has been made, and there are enough data to permit the specification of tentative standards in evaluating noise levels.

Fig. 9 shows a set of sound level criteria. Each curve represents a particular effect on human activity. The top curve shows the "Deafness Risk" criterion. This is the maximum noise level allowable in each of the eight octave bands for an individual exposed for a full working day over a long period of time. Evidence indicates that no hearing impairment occurs if the noise level is kept below this criterion. For present day jet aircraft, "Deafness Risk" levels occur only at fairly short distances from the engine.

The lowest curve presents "Sleep and Rest" criteria. People in houses and hospitals probably should not be subjected to noise above these levels, particularly at night. Usually, rest and relaxation will be very little disturbed in most cases, if the noise level remains below this curve. However, if the noise spectrum is unusual, maybe having one or two outstanding tones, or if the noise occurs suddenly and unexpectedly, rest may be disturbed.

Between the two extremes are the "Speech Interference Level" (SIL) curves. These curves can be used as the basis of providing a nearly non-subjective criterion for evaluating the effect of noise on voice communication. Nearly all the information in speech is contained in the frequency region from about 200 to 6000 cps. Background noise in this frequency region limits the dynamic range useful in satisfactory speech transmission. Since the limitation is associated with masking speech, the effect of background noise is to decrease intelligibility.

In order to evaluate background noise, the frequency region involved in speech can be divided into a number of bands of equal importance to intelligibility. Then the total intelligibility can be determined by averaging the contributions of the various bands according to empirically verified methods.

For many noises this procedure can be simplified. An approximate measure of the interference of a noise with speech communication is obtained by averaging the sound pressure level in decibels of the three octave bands from 600 to 4800 cps. The resulting factor is called the Speech Interference Level (SIL). If the sound pressure level in the 300 to 600 cps band is more than 10 db above that of the 600 to 1200 cps band, improved accuracy is obtained if all

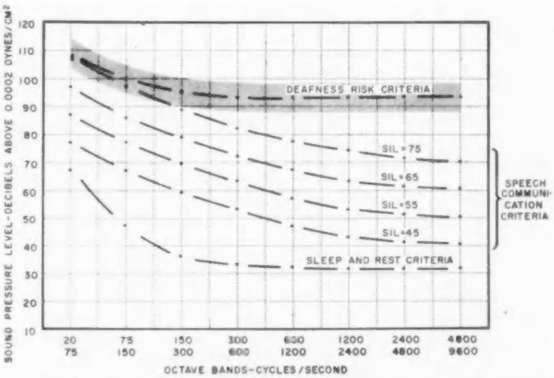


Fig. 9—Noise levels—human tolerance criteria. Each curve is correlated with some particular effect on human activity.

Table 1—Maximum Values of Speech—Interference Levels of Noise in the Presence of which Entirely Reliable Speech Intelligibility will be Obtained for Average Voices and Hearing

	SILS			
Distance from Speaker (ft)	Voice Normal	Voice Raised	Voice Very Loud	Voice Shouting
0.5	71	77	83	89
1	65	71	77	83
2	59	65	71	77
3	55	61	67	73
4	53	59	65	71
5	51	57	63	69
6	49	55	61	67
12	43	49	55	61
24	37	43	49	55

four bands are averaged. If the slope of the intensity curve is greater than about 10 db per octave, the accuracy of the method is reduced somewhat.

To determine the significance of SIL, it is necessary to specify the level of the speech itself. If two men having average voices and good hearing are facing each other in a noise field, reliable communication can be established between them under various background noise levels and distances as shown in Table 1. If a restricted prearranged vocabulary is used, the permissible SIL can be increased by about 5 db. If a woman is speaking, the permissible level should be decreased by about 5 db. So, SIL is a rating of background noise which can be used in connection with the "Maximum Value" table (Table 1) to determine the conditions under which completely intelligible speech communication can be maintained.

It will be noted that the SIL curves are extended beyond the octaves considered important for speech intelligibility even though noise energy in the lower frequency bands at the criterion level of SIL 45 does not interfere seriously with speech communication. This is done because disturbance or discomfort aside from speech interference may occur through its presence, and the extension of the SIL curves in this region is an attempt to correlate such disturbance with the speech interference.

With these considerations in mind, a SIL criterion has been selected which we believe defines the area of freedom from unreasonable interference with most human activities. This criterion is the lowest SIL curve, SIL 45, shown in Fig. 9. Table 1 shows that this would permit the unimpaired understanding of a man talking in a somewhat raised voice at about 20 ft. We have also included data on SIL 55 in our analysis for purposes of comparison. These data were determined in the same way as the SIL 45 data. Note that for speech to be understood at 20 ft, with a background noise of SIL 55, shouting is necessary and this is obviously detrimental to many normal activities. At 55 SILs, a normal voice level is sufficient at 3 ft, and a raised voice at about 6 ft. Of course, a noise of 55 SILs in an outdoor area may create a SIL value of 45 or less indoors, near by.

A subject tends to become used to ambient noise through experience. After a period of indoctrination it annoys him less than it would a newcomer. But practice or experience is of minimal value in im-

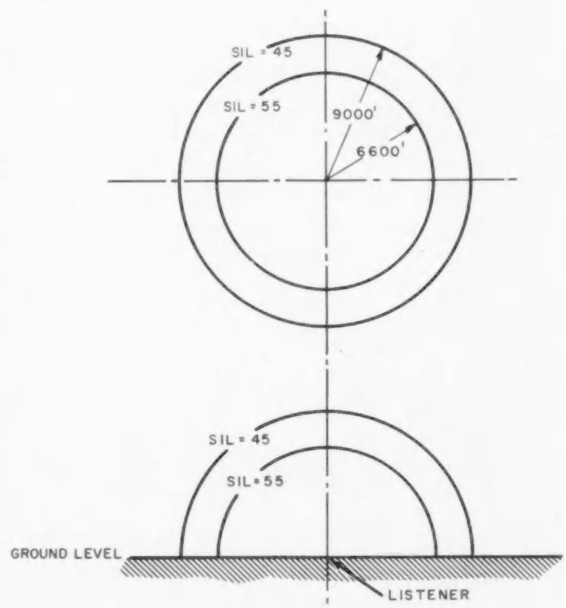


Fig. 10—A scale drawing of the igloos of maximum Speech Interference Level for a six engine B-47 airplane on straight flight.

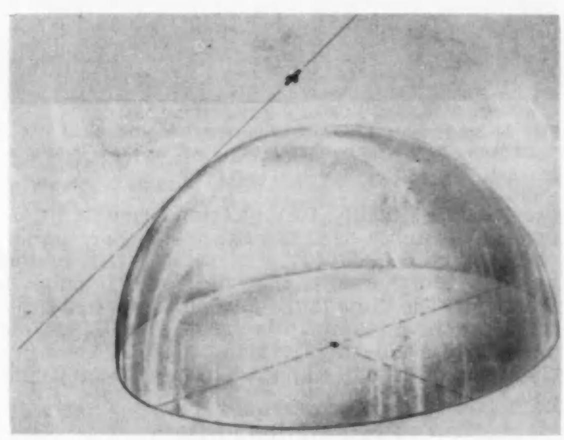


Fig. 11—Isometric of a typical sound control hemisphere. At the center of this hemisphere the sound level will not exceed a specified criterion value if the B-47 aircraft does not penetrate the surface.

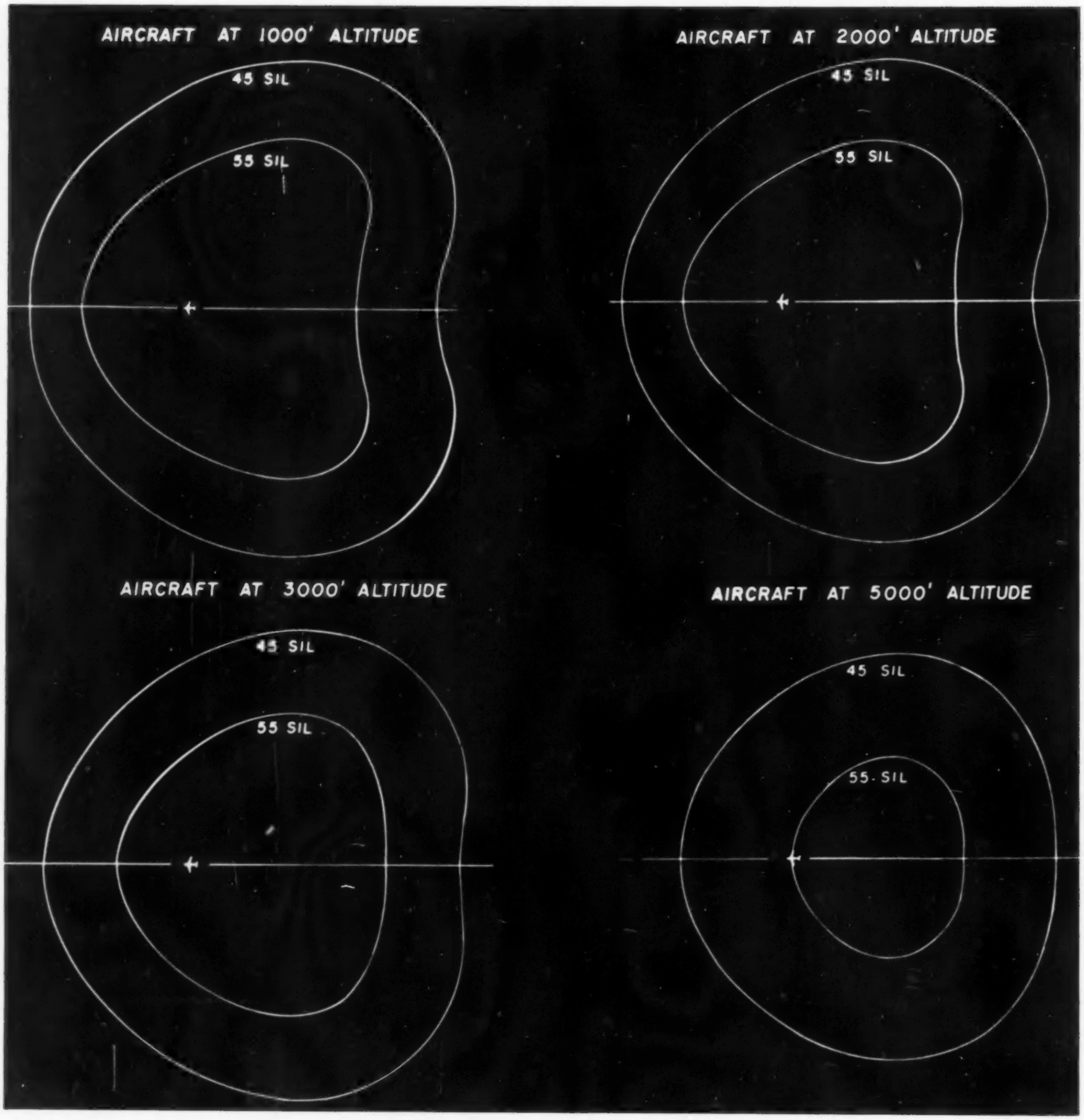


Fig. 12—Isosilic contours (ground plane curves) for altitudes of 1000, 2000, 3000, and 5000 ft. Scale is 5000 ft to the inch. These curves are constructed on a transparent overlay in practice and are useful in noise evaluation.

proving one's ability to understand speech in the presence of noise near the SIL level where understandability is reduced for a person with normal hearing. Furthermore, the effect of SIL values is practically the same for people with impaired hearing. For these reasons, the use of the SIL scale as a means of evaluating the significance of noise in a classroom or an office appears to be especially suitable.

Presentation of Data

Two methods are used for presenting SIL data. Both methods can be used to portray graphically the effects of aircraft noise in terms of any of the human tolerance criteria discussed above as well as any others that may be devised. Note that the methods can be used to study the effect of any aircraft noise source, provided the noise characteristics of the source have been specified. In the following example, the methods are used to study the effect of B-47 airplane noise on speech communication.

One method uses imaginary concentric hemispheric domes or "igloos." The center of the igloo is a point on the ground occupied by the observer. The radius of each igloo is determined by a specific value of SILs, and represents the surface which a

B-47 airplane flying a straight course may not penetrate without risk of exceeding the criterion value of that igloo at its center point.

A scale drawing of these igloos is shown in Fig. 10. Fig. 11 is a perspective of a typical sound control hemisphere. The assumptions made in Figs. 10 and 11 were:

1. B-47 airplane, without afterburner, and at stated power setting.
2. Straight flight path.
3. Engine speed, 7850 rpm (near 100% take-off power).
4. Directivity pattern symmetrical about the longitudinal axis of the airplane.
5. Air attenuation values equal in all directions.
6. Specific noise spectrum around airplane as discussed above.
7. No ground attenuation.

Under the assumptions, the igloo is independent of direction of flight and ascent or descent of the airplane. It is, therefore, a perfect hemisphere. Actually the edges of the igloo at the ground should be turned in somewhat to account for ground attenuation. We have neglected ground attenuation because it is fairly unimportant for airplanes at altitude.

It is seen that the airplane can approach no closer than 9000 ft to the ground point without exceeding 45 SILs. In loudness terms, the same airplane could approach as close as 5800 ft before exceeding a level of 80 phons (about equal to superhighway traffic at 100 ft), but this involves interference greater than 55 SILs. The 80 phon criterion, which is sometimes used, is not interchangeable with the 45 SIL criterion and is less dependable.

The second method of presenting data uses a three-dimensional isosilic imaginary surface which travels with the airplane. This surface includes all points in space representing a constant SIL value. Such a dynamic body is shown in perspective in Fig. 6. Note that a similar body can be constructed for any noise source and type of criterion.

The surface intersects the ground plane in a curve, enclosing an area which diminishes and changes shape as the altitude of the airplane increases. Several sets of these ground plane curves are shown in Fig. 12. These curves are to be scaled to match the scale of the chart being studied, and they are conveniently constructed in the form of transparent overlays. Their convenience in noise evaluation studies is apparent from the following example.

On a properly scaled map of the area in question, desired flight paths are laid out, with corresponding altitudes indicated. Then, by orienting the proper overlay along some particular flight path, the maximum speech interference level is obtained for the bordering regions by observing which contours touch the points that are being evaluated. The flight axis on the overlay should be kept tangent to the flight path.

The same assumptions were made in deriving these contours as were made in determining the igloo radii except that straight flight paths need not be assumed. The longitudinal axis of the airplane is assumed to be level at all times, since the B-47 airplane climbs at relatively small geometric angles any error resulting from this assumption will be small.

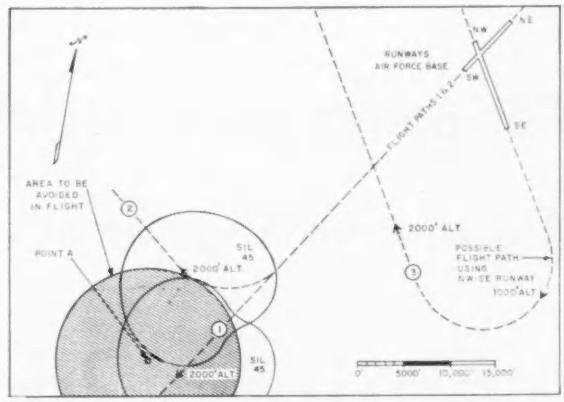


Fig. 13—Flight path map photographed with overlays superimposed. Point A is the observation point. If the airplane penetrates the cross-hatched area, point A is subject to more than 45 SILs and this area, therefore, should be avoided.

As an illustration of the use of the overlay, a chart of a representative region is shown in Fig. 13 with photographed overlays of proper scale superimposed. A ground point "A" is assumed to be located in the vicinity of a typical air base that has two intersecting runways. Several hypothetical flight paths are shown on the chart, along with altitude indications based on take-off and climb performance of a B-47 airplane.

If the airplane takes off along flight paths 1 or 2 its altitude will be about 2000 ft as it approaches point A. For illustration, the curve of the SIL 45 ground intersection is drawn in several locations on the chart. In practice, suitable overlays can be moved about in simulation of reasonable flight paths to delineate an area over which aircraft should not fly if chosen noise criteria are not to be exceeded. The cross-hatched area around point A has been determined in this manner. Take-offs along path 1 are in violation of the assumed 45 SIL limit, while path 2 is acceptable.

The problem will not be as severe if the other runway shown on the chart is used for the take-off because the airplane can be at a greater altitude if it should approach point A.

In instrument landings, the airplane is generally aligned with the runway while it is still a long distance away from the airport. So, it is possible that the flight path will cut through the designated area when making a NE approach. While full power will not be used during the approach, the noise level at point A may still be higher than the tolerable level. To avoid exceeding SIL 45 in landing on instruments, the aircraft must use some other approach than path 1, and possibly would have to be restricted to some other runway if local flight instrumentation were versatile enough to permit and if local wind were not unfavorable for the change.

For complete paper (in multilith form) on which this abridgment is based, write SAE Special Publications. Price: 35¢ to members, 60¢ to nonmembers.

Comparing the free and fixed gas turbine engines as . . .

Powerplants for

COMPARISON of free and fixed turbine engines as powerplants for helicopters reveals that:

The loss in maximum available horsepower with reduced rotor speed for the fixed turbine engine may not be so drastic as to rule it out. The free turbine engine requires rotor accelerations with its attendant problems for thrust modulation whereas the fixed turbine can, and probably should, operate as a "constant-speed-machine."

It seems that over-temperature and over-speed problems are more severe for the free turbine engine, probably requiring at least an over-speed governor on the gas generator rotor. The stability characteristics of the free turbine may be superior, but no unstable tendency was dicovered for several fixed turbine engines studied.

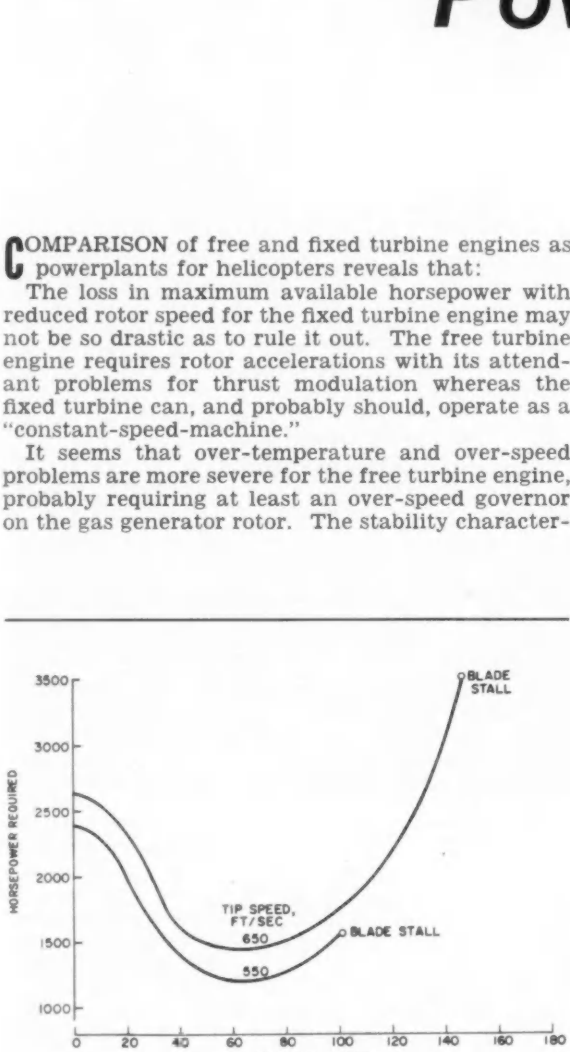


Fig. 1—Shown are the power requirements of a 30,000 lb helicopter for rotor tip speeds of 550 and 650 fps. Note that it is best to hover (zero flight speed) at a low tip speed and to use a higher tip speed for forward flight.

Helicopter Power Requirements

The demands made by a helicopter upon its powerplant are shown in Fig. 1. The horsepower required by the helicopter is plotted against forward flight speed for two rotor tip speeds, 550 and 650 fps. Values given are representative of a 30,000 lb, transport-type helicopter. The droop in the power curves is a result of the changing profile and induced drags of the rotor and the increasing parasite drag of the fuselage as flight speed is increased.

For a given tip speed, power required in hovering flight, represented by the intersection of the curves with the vertical axis at zero forward speed, is shown to be nearly twice the power at minimum-power forward flight speed. Furthermore, for the rotor configuration represented by Fig. 1, power required during any flight condition is higher for the higher tip speed. Retreating blade stall is delayed at the higher tip speed and maximum flight speed is greater as shown by comparison of the circled points.

Fig. 1 shows the aerodynamic advantage afforded by a variable tip speed rotor. Considering rotor power required, it is best to hover at a low tip speed and to use a higher tip speed when forward flight is desired.

Engine Characteristics

In Fig. 2 specific fuel consumption is plotted as a function of shaft horsepower for a single-shaft fixed turbine. The plot is valid for rated shaft speed, and lines of constant turbine-inlet temperature and constant exhaust-nozzle area are shown. Because of the comparatively low forward speed of the helicopter, no effort was made in the powerplant analysis to obtain useful thrust from the gas-turbine jet.

Maximum exhaust-nozzle area operation was

W. S. Miller, Jr., R. P. Krebs, and T. C. Blaschke,
Lewis Flight Propulsion Laboratory, National Advisory Committee for Aeronautics

Excerpts from paper "Shaft Gas Turbines for Helicopters" presented at the SAE Golden Anniversary Aeronautic Meeting, New York, April 20, 1955. This paper will be published in full in the 1956 SAE Transactions

Tomorrow's Helicopters

therefore assumed and Fig. 2 shows that this is the operational mode that gives best fuel economy. Nozzle areas smaller than maximum—in this case 1.4 times the compressor area—give higher specific fuel consumptions.

When the nozzle area is held constant, higher turbine-inlet temperatures increase the available power and reduce the specific fuel consumption. Turbine temperatures are limited to the specified maximum allowable turbine temperature shown in Fig. 2.

Plots similar to Fig. 2 can be made for the gas turbine running at speeds lower than rated shaft speed. In these plots, specific fuel consumption, at a given percentage of rated power, is found to be slightly improved over the values shown on the rated speed plot. The temperature limit line will also move to the left, giving lower obtainable horsepowers for the maximum nozzle area.

Fig. 3 is a plot of specific fuel consumption for the free turbine at rated shaft speed. Lines are shown giving nozzle area limits, turbine-temperature limits for the gas generator, and constant gas-generator speed. Like the single-shaft fixed turbine, the free turbine gives best fuel economy when the exhaust-nozzle area is held at its maximum permissible value.

The maximum horsepower obtainable from the free turbine is limited either by the temperature

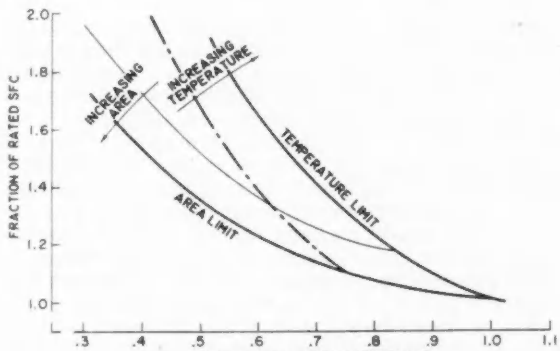


Fig. 2—Shown is a plot of specific fuel consumption vs. shaft horsepower for a single-shaft fixed turbine running at rated speed. When the nozzle area is held constant, higher turbine-inlet temperatures increase the available power and reduce the specific fuel consumption.

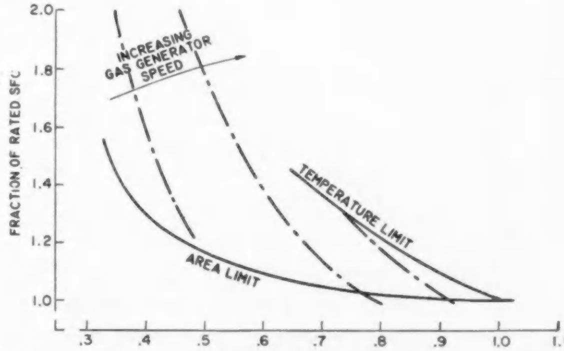


Fig. 3—This is a plot of specific fuel consumption for the free turbine at rated shaft speed. The maximum horsepower obtainable is limited either by the temperature limit on the gas-generator turbine or by the limiting speed of the gas generator.

limit on the gas-generator turbine or by the limiting speed of the gas generator. The power output of the free turbine, for fixed shaft speed, can only be changed by varying the rotational speed of the gas generator if the exhaust-nozzle area is held constant. Plots similar to Fig. 3, constructed for free turbine speeds less than rated, show small improvements in specific fuel consumption for a given horsepower.

The minimum specific fuel consumption curves for the fixed and free turbines, shown in Figs. 2 and 3, have been replotted for comparison in Fig. 4. As power is reduced from the rated value, the specific fuel consumption for the fixed turbine increases more rapidly than for the free turbine. At 0.5 rated power, for example, the specific fuel consumption of the fixed turbine is 15% higher than for the free turbine.

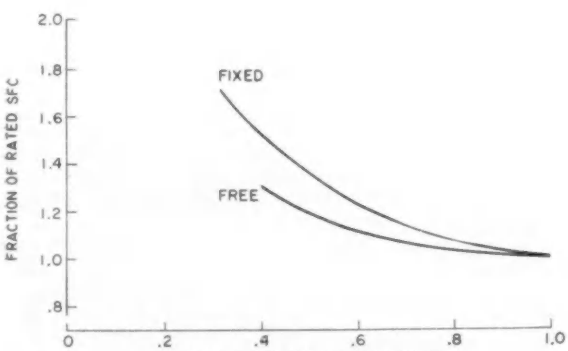


Fig. 4—This replot of Figs. 2 and 3 shows that the fuel consumptions for the fixed and free turbine engines are equal at rated power. As power is reduced from the rated value, the specific fuel consumption for the fixed turbine increases more rapidly than for the free turbine.

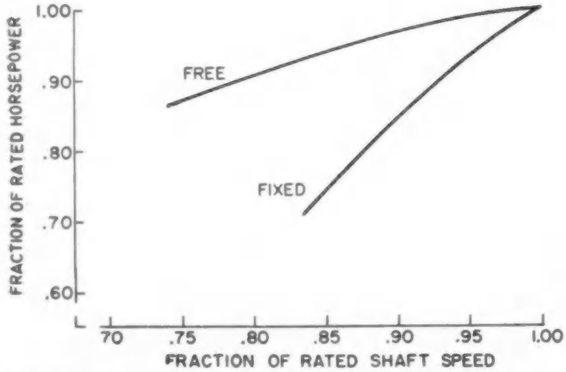


Fig. 5—Shown is maximum available shaft power plotted as a function of shaft speed for the fixed and free turbine engines. Power changes with free turbine speed variations are due to small changes in turbine efficiency. A change in speed of the fixed turbine gives a simultaneous variation in both airflow and pressure ratio. So, power drops off sharply as shaft speed is reduced.

Maximum available shaft power is plotted in Fig. 5 as a function of shaft speed for the fixed and free turbine engines. It has been shown that maximum power, at a given speed, is determined by limiting turbine-inlet temperatures and exhaust-nozzle areas. Since the free turbine is choked at design point, and remains choked during power modulation because of the large nozzle area, changes in free turbine speed little effect the gas generator section.

Power changes with free turbine speed variations, therefore, are due primarily to small changes in turbine efficiency. Because these differences in turbine efficiencies are small, the maximum available power curve for the free turbine is quite flat.

On the other hand, a change in the speed of the fixed turbine gives a simultaneous variation in both airflow and pressure ratio. So, when compared to the free turbine, shaft power drops off sharply as shaft speed is reduced. At 0.85 rated speed, for example, the shaft power of the free turbine is 0.93 of rated while that of the fixed turbine has fallen to 0.75 of rated power. Overspeeding of the fixed turbine gives an increase in airflow and pressure ratio, and powers greater than rated values can be obtained.

With the free turbine, power cannot be increased beyond rated values by overspeeding unless the free turbine efficiency is increased. The shapes of the curves plotted in Fig. 5 are dependent upon the characteristics and matching of the gas-turbine components. Both engine types employed conservatively designed axial-flow compressors with low axial Mach numbers. Compressor efficiency peaked at about 0.93 rated shaft speed. As far as possible, similar component characteristics were used for both the fixed and the free turbines.

Flight Performance

A convenient means of evaluating the combined effect of engine specific fuel consumption, power-speed relationship, and engine size is to compute the resulting performance which comes from installing several turbine engines in an assumed helicopter. The helicopter used in this study had a gross weight of 30,000 lbs, carried a crew of two, and completed all its missions with a 10% fuel reserve on board.

Three missions were considered: ultimate range with no payload, 300 nautical miles at the forward speed corresponding to best range, and 3 hr of hovering at standard atmospheric conditions. Three gas turbines were used as powerplants: one free turbine and two fixed turbine designs. All the engines were sized to have at least 30% power reserve at sea level hovering. Forward flight was conducted with all engines at rated engine speed.

Fig. 6 shows how the engine size is determined. The flight condition and operating point at which engine speed and rotor speed are matched in the helicopter design are called the engine-rotor match point. The rotor power requirements in hovering flight are shown as a function of tip speed on both sides of Fig. 6 by the lower solid lines. On the left side of the figure, the match point for the free tur-

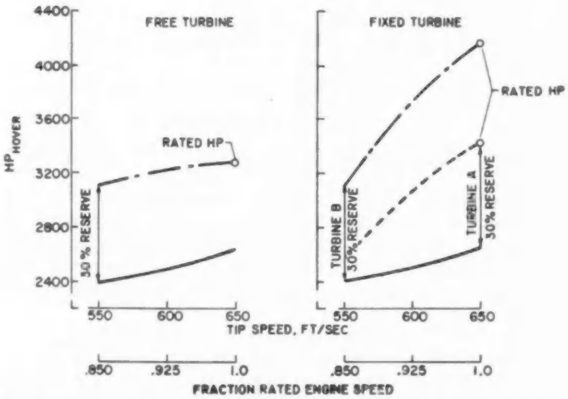


Fig. 6—Rotor power requirements in hovering flight are shown as a function of tip speed on both sides of the figure by the lower solid lines. On the left side, the match point for the free turbine is set at 550 fps tip speed. For fixed turbine A, which runs at constant shaft speed, the match point was set at 650 fps, corresponding to rated engine speed. Fixed-turbine B, which runs at variable speed, matched in hovering at 550 fps.

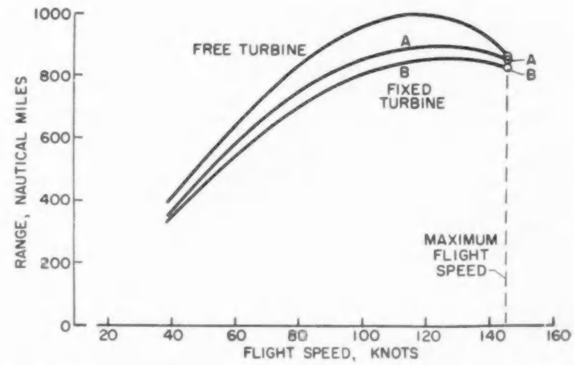


Fig. 7—The ultimate range given by the three engine designs is shown as a function of helicopter flight speed. Forward flight was at 650-fps tip speed. Maximum flight speed is identical for the three helicopters and maximum range is obtained at about equal speeds. Note that the free turbine has the longest ultimate range.

bine is set at 550 fps tip speed, corresponding to 0.85 engine rated speed.

Since the reserve power requirement was 30% over hovering power, the free turbine engine was sized to provide 3100 hp at 0.85 rated speed. The dashed power-speed curve for the free turbine is relatively flat and shows that this engine, matched to the rotor at 0.85 speed, will develop 3280 hp when its speed is raised to rated value.

For the fixed turbine A, which runs at constant shaft speed, the match point was set at a rotor tip speed of 650 fps, corresponding to rated engine speed. To provide the necessary reserve power at hovering tip speed, turbine A was sized to provide 3410 hp and its power-speed characteristic is given by the lower dashed line.

Similarly, fixed-turbine B, which runs at variable speed, matched in hovering at 550 fps and 0.85 engine speed. To provide reserve power, it must develop 3100 hp at this speed and, because of its steep power-speed characteristic, will provide 4260 hp when speed is raised to rated. Fig. 6 graphically demonstrates that fixed turbine B is a considerably larger engine than either the fixed turbine A or the free turbine.

The ultimate range given by the three engine designs is shown in Fig. 7 as a function of helicopter flight speed. Because forward flight was carried out in each case at the same rotor tip speed—650 fps—maximum flight speed is identical for the three helicopters and maximum range is obtained at about equal speeds.

Fig. 7 shows that the free turbine has the longest ultimate range and the constant-speed fixed turbine is next. In a mission of this type, which could possibly be a ferry flight, power requirements are reduced steadily as fuel is burned and the helicopter lightens.

As the engine operates further from rated power, the specific fuel consumption of the fixed turbine

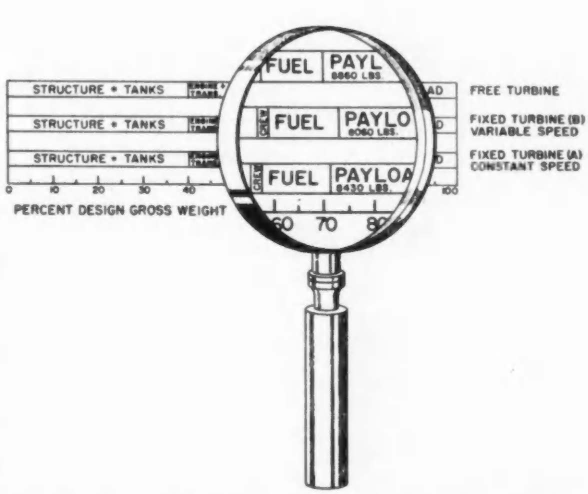


Fig. 8—This payload comparison of the three engines for a 300-mile mission shows that the free turbine carries the heaviest payload.

engine becomes increasingly greater than that of the free turbine. It is apparent, therefore, that a mission of this type, involving considerable off-design operation of the powerplant, presents more unfavorable conditions for the fixed turbine than for the free.

If part of the initial fuel aboard is replaced by payload and the mission range is limited to 300 miles, the off-design requirements made on the powerplant are not so severe. In Fig. 8, the payload that can be carried on a 300-mile mission is used as a figure of merit for the three powerplants.

The free turbine is shown to carry the heaviest payload, 8860 lb, while the fixed turbine A, which operates at constant shaft speed, can carry 8450 lb. The compromise fixed turbine B, since it is a larger

Table 1—Performance Summary

	Ultimate Range, %	Payload for 300-Mile Mission, %	Payload for 3-Hr Hovering Mission, %
Free Turbine	100	100	100
Fixed Turbine A, Constant Rotor Speed	90	95.5	92.5
Fixed Turbine B, Variable Rotor Speed	85	91	94.5

engine than turbine A, operates further off design during the flight and its payload capacity is 8060 lb for the mission.

Similarly, hovering performance with payload was calculated for the three powerplant installations. Here, a 3-hr hovering mission, such as might be required in antisubmarine warfare, was assumed. These results are summarized, along with the forward flight results, in Table 1.

The free turbine again carried the heaviest payload for the 3-hr flight. Fixed turbine B, which was allowed to hover at a tip speed that corresponds to 0.85 engine speed, carried about 5.5% less payload than the free turbine. Fixed turbine A, hovering at the high tip speed, carried about 7.5% less payload than the free turbine.

This payload comparison in hovering flight presents an interesting question: What happened to the appreciable rotor-power advantage that was predicted for the helicopter hovering at low tip speed? Although the helicopter with fixed turbine B was operated at a tip speed of 550 fps, it had only slightly better payload capacity for the 3-hr flight than fixed turbine A, which hovered at 650 fps.

The answer to this apparent anomaly is found mainly in the fact that all engines were sized to have 30% reserve power at sea-level hovering tip speed. To develop this reserve at 0.85 rated shaft speed, turbine B had to be a larger engine than either turbine A or the free turbine.

Since it was further off-design in sea-level hovering flight, its off-design fuel consumption was much poorer than either of the other engines. Furthermore, since a rotor torque increase accompanied the tip speed decrease, the reduction gear required with turbine B was heavier than that used with turbine A, giving an additional payload penalty.

The flight performance comparisons given underline certain differences in the basic characteristics of fixed- and free-turbine powerplants. For example, when the fixed and free turbines are operated at the same fraction of rated power the free turbine has the better specific fuel consumption as reflected in its superior ultimate range.

Also, when either powerplant is designed for low tip speed hovering flight and high tip speed forward flight, the free turbine engine gives a lighter powerplant because of its flatter horsepower-shaft speed characteristic.

Since the performance advantages illustrated were not overwhelming, it was considered advisable to examine the control and stability characteristics of both turbines to see if the advantage again lies with one or the other engine type.

Control Characteristics

The most pertinent engine characteristics applicable to problems dealing with changes in operating variables are the horsepower-rotor speed and torque-rotor speed curves. The maximum horsepower-rotor speed characteristic for the free-turbine engine is shown in Fig. 5.

The operational advantage in a free-turbine engine of a rather flat horsepower-rotor speed curve allows a better choice of rotor speeds for the range that is required from hovering to maximum forward flight speed. It relaxes close control of rotor speed and provides restoring power should the rotor speed be suddenly reduced, as by a gust load.

Yet, the fixed turbine engine has been pictured as having a steep maximum horsepower-rotor speed curve, requiring near maximum rotor speed for any appreciable horsepower and giving little, if any, excess power at reduced rotor speeds—even to the extent of instability. Our studies do not bear out this gloomy picture.

The calculated characteristic for the fixed turbine engine used in the foregoing performance studies is shown in Fig. 5. While the free turbine engine is undeniably superior in this regard, showing a loss in power of only 4% for a 10% reduction in rotor speed, the fixed turbine engine shows the not too drastic loss of 15% for the same 10% rotor speed reduction.

This more hopeful characteristic of the fixed turbine engine may be attributed in part to the use in our studies of an axial flow compressor which has a flatter air flow-compressor speed characteristic than that obtained using centrifugal compressor engines.

Engine Acceleration and Thrust Modulation

The maximum available power curves for these engines do not imply the ease or difficulty of realizing this power, of accelerating the engine or rotor, or of varying the thrust. For the free turbine engine, all power changes require changes in the gas generator speed.

Thrust modulation is dependent on the acceleration of the gas generator rotor and involves the difficult problems of compressor stall, temperature and combustion limits. The gas generator, like a turbojet engine, may require as much as 5 to 6 sec to go from idle to full speed.

Note that the fixed turbine engine can be operated as a "constant-speed-machine" as almost the full range of powers is available at constant rotor speed. This aspect of the fixed-turbine engine may be used to simplify helicopter operation and control, to allow very rapid thrust modulation (as fast as fuel flow rate and rotor blade angle can be varied) and to bypass the entire problem of rotor accelerations.

Performancewise it has already been shown that

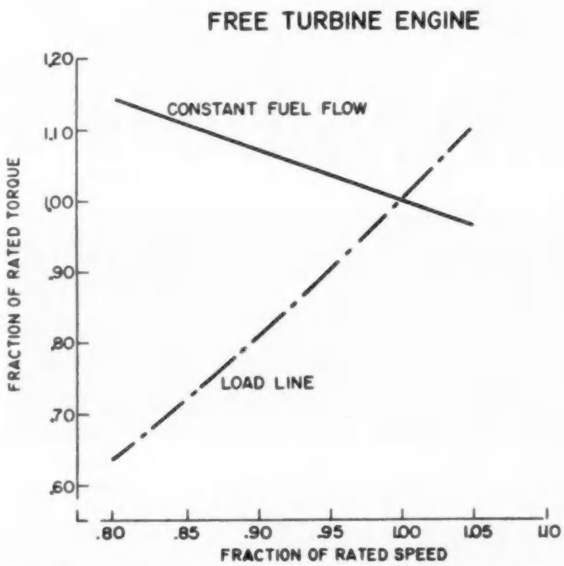


Fig. 9—The expected characteristics of the free-turbine engine are shown here. Static stability results when the slope of the load line is greater than that of the engine as is the case here.

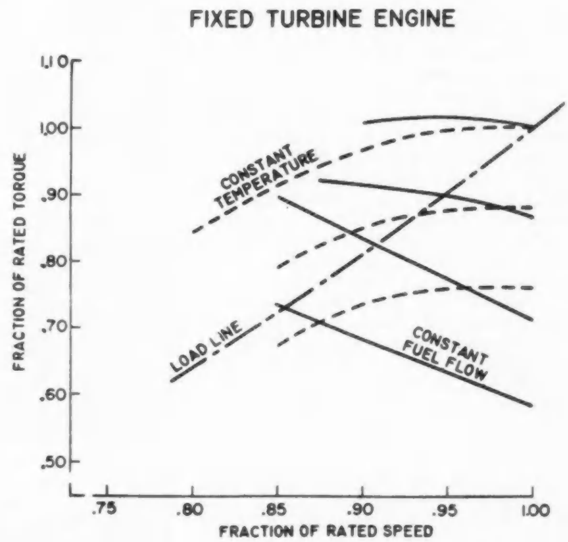


Fig. 10—Shown are the torque-speed curves at constant fuel flow and at constant temperature along with the load line. Even where the temperature line has a positive slope, the fuel-flow line may be flat or have a negative slope.

a fixed-turbine engine designed for constant rotor speed is somewhat better than one designed to hover at lower speeds because it is operated closer to its design point. For the foregoing reasons, it seems that the over-temperature problem for the free-turbine engine is more critical.

Maximum or over-temperature is required for aceleration of the gas generator rotor in any reasonable time, and any inadvertent or emergency power over-temperature at maximum power would give simultaneous over-speed. For the fixed-turbine engine, over-temperature might be tolerated at reduced rotor speeds for transient bursts of power. Emergency power application would not involve any over-speeding.

Engine-Rotor Static Stability

For considerations of stability of an engine-rotor system, the pertinent characteristics of the engine are the horsepower-speed or, better, the torque-speed curves at constant fuel flow. The pertinent characteristics of the rotor are the torque-speed curves at constant blade angle. The expected characteristics of the free-turbine engine are shown in Fig. 9. Static stability results when the slope of the load line is greater than that of the engine as is the case here.

The corresponding torque-speed curve for the fixed-turbine engine has sometimes been represented as having a highly positive slope, sometimes even more positive than the load line implying the fixed-turbine engine rotor system to be unstable. Furthermore the performance line (constant temperature) and the stability line (constant fuel flow) are sometimes used interchangeably.

Our studies of a fixed turbine engine are shown in Fig. 10 for the torque speed curves at constant fuel flow and at constant temperature along with the load line. No unstable tendency is indicated. Even where the temperature line has a positive slope, the fuel flow line may be flat or have a negative slope. There is no reason for suspecting the fixed-turbine engine to have less stability than a turbine-propeller engine.

The stabilizing characteristic for the fixed-turbine engine is an inherent feature of a compressor-burner-turbine combination. The free-turbine engine has all its damping action in the power turbine and uses almost none of the gas generator damping.

For the fixed-turbine engine shown the operating point chosen would influence the slope of the torque-speed curve at that point. It seems that the rotor can be matched to the engine for best performance without introducing static stability problems.

Engine-Rotor Frequency Responses

Frequency response studies showed that the fixed- and free-turbine engines were equally fast, but that the free-turbine was more resonant. The fixed-turbine engine shaft torque response is more sensitive to rotor loads than the free-turbine engine. Both engines require lag hinge dampers.

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About SAE Members

JAMES D. REDDING has been appointed headquarters sales manager for the Westinghouse Aviation Gas Turbine Division, Westinghouse Electric Corp.

Redding will be in charge of the company's aircraft engine sales effort in the central area, which covers the midwest and southwest United States, including an office in Dayton, Ohio.

He joined Westinghouse in October, 1954, in the position of staff assistant to the chief engineer. His entire professional career has been in aviation since his graduation from the University of Michigan in 1930. He has been associated with Consolidated Aviation, Curtiss-Wright Corp., the Civil Aeronautics Administration, and moved to Westinghouse from the staff of the Assistant Secretary of Defense, Research and Development.

Redding was SAE 1955 vice-president representing Aircraft Activity.

WILLIAM B. BERGEN has been elected to the board of directors of RIAS, Inc., a new subsidiary of Glenn L. Martin Co. The new company has been formed to conduct research in basic science.

Bergen is executive vice-president of Glenn L. Martin Co.

WILLIAM CLAY FORD has been named Detroit's Outstanding Young Man of 1955. He was honored in absentia at a dinner sponsored by the Junior Board of Commerce.

Ford has been confined to his home since Dec. 11, when he snapped a tendon in his left foot.

The 30-year-old vice-president of Ford Motor Co. was represented at the dinner by his brother Benson, winner of the 1951 award.

In announcing the award, the eight-man selection committee said:

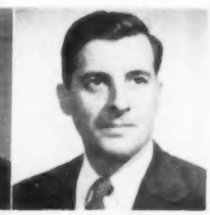
"Mr. Ford's personal qualifications and business achievements have been demonstrated by his assumption and discharge of increasing responsibility in a large industry within a relatively brief period of time."

MARTIN D. ARCHANGELI has been named assistant general manager of Saginaw Division, Eaton Mfg. Co. He had been serving as general sales manager of Saginaw, Valve, and Aircraft Divisions. He joined Eaton in 1922 in the Saginaw production-planning department.

ROY I. ANDERSON has joined General Electric Co., Decatur, Ill., as a product engineer. He is now concerned with sales engineering, manufacturing engineering, and engineering development for silicon rubber and poly vinyl chloride fabrication.

Anderson had been a shift superviser for E. I. du Pont de Nemours & Co., Inc., Circleville, Ohio.

Redding



Bergen

W. C. Ford

Archangeli

Johnson

Toeplitz

Connor

Hirsch

HAROLD O. JOHNSON has been named chairman of the board of directors and treasurer of Bound Brook Oil-Less Bearing Co. He has been executive vice-president and treasurer. Johnson has been a member of the Bound Brook organization since 1921.

WILLIAM R. TOEPLITZ was named president of the company and **SAMUEL S. CONNOR** was named vice-president and secretary.

Toeplitz has been with the company since 1935, when he joined as a metallurgical engineer. He fills the position formerly held by **WILLIAM FISHER JENNINGS**, who died in September.

Connor, who advances from the post of sales manager to his new position, started with the company as a sales engineer in 1945.

SHANE H. BRADY is now a member of the Sales Development Department, Euclid Division, GMC. He had been a sales engineer for American Brakeblok Division of American Brake Shoe Co.

RAYMOND G. BENNETT has been appointed to the newly created position of administrative chief engineer of Electric Auto-Lite Co. He will direct and coordinate engineering division personnel and administer supporting activities to technical engineering work.

Bennett has been a senior mechanical engineer for the company since 1953.

CHET D. HIRSCH is heading a new service program for Allen Electric and Equipment Co. as newly appointed service manager.

He had been educational director for Bendix Products Division, Bendix Aviation Corp.

ROBERT GRANT, vice-president of Standards Products Co., is now operations manager as well. He has been in charge of manufacturing at the company's six plants for the past three years. He is a member of the management policy committee. **F. R. VALPEY**, senior vice-president, has been named chairman of the management policy committee. **BEECHER B. CARY**, director of research and engineering, has also been named to the management policy committee.

ARTHUR B. ARNOLD has been appointed to the newly created post of consulting engineer—Manufacturing Division, Modine Manufacturing Co. He has served Modine 29 years as an engineer and most recently held the position of manager of operations.

DELMAR E. BENJAMIN has taken a position with North American Aviation, Inc. as a research engineer. He has been a fuels and lubricant engineer with Cleveland Diesel Engine Division, GMC.


Shirtzinger


Brown


H. S. Ford


Hulsing


Conlon


Witbeck


Hobbs


Murray


Wells


Saut


Price


Thompson

EMERSON W. CONLON has been named general manager of the newly acquired Turbomotor Division of the Curtiss-Wright Corp. in Hempstead, N. Y. He has been serving as director of engineering with Fairchild Engine Division, Fairchild Engine & Airplane Corp.

NORMAN C. WITBECK has been appointed to the position of chief engineer of the new Division. He has also been associated with Fairchild Engine Division as a project engineer.

JOHN W. HOBBS, president of the John W. Hobbs Division of Stewart-Warner Corp., has been elected to the Corporation board of directors. The Hobbs Division was purchased by Stewart-Warner in July, 1955. It was established by John Hobbs in 1938.

W. M. MURRAY, vice-president of Deep Rock Oil Co., has been elected 1956 president of the National Lubricating Grease Institute. **J. W. LANE**, manager of Socony Mobil Oil Co.'s Automotive Division Lubricating Department, was elected vice-president. At the same time **A. J. DANIEL**, president of Battenfield Grease and Oil Corp., was elected treasurer.

Directors of the Institute include **H. L. HEMMINGWAY**, manager of the Sales Service Departments, Pure Oil Co.; **C. L. JOHNSON**, president of Jesco Lubricants Co.; and **H. A. MAYOR, JR.**, executive vice-president, Southwest Grease and Oil Co.

HAROLD E. WELLS has been appointed chief engineer at the newly formed aircraft hydraulics engineering group, Bendix Products Division, Bendix Aviation Corp.

For the past 19 years, Wells has been associated with Bell Aircraft Corp. He had lately been serving as staff engineer in the Bell General Engineering Laboratories.

JULES F. SAUT has been named manager of sales to the automotive industry for Reynolds Metals Co. He has been a representative of Reynolds in the Detroit area since 1947.

EDMUND T. PRICE, who has been serving as president and general manager of Solar Aircraft Co., has been named chairman of the board. He will remain as Solar's chief executive officer under the new arrangement.

WARREN THOMPSON, formerly assistant director of the Research and Development department of D-X Sunray Oil Co. in Tulsa, has been named manager of the company's Research and Technical Service Division. D-X Sunray is the refining and marketing subsidiary of Sunray Mid-Continent Oil Co.

J. F. SHIRTZINGER, president of Hammond Manufacturing Corp. and its wholly owned subsidiary, Air Logistics Corp., announces the merger of the two corporations. Change-over to the single corporation to be known as Air Logistics Corp. was effective Dec. 1, 1955.

The merger of the two corporations, Schirtzinger explains, has been occasioned by the expansion in scope of the Air Logistics Corp. activities and because it is felt that its name is more indicative of the nature of future operations. Hammond Manufacturing will continue operation as a Division of Air Logistics Corp.

Air Logistics Corp. was formed in March, 1955, and Hammond Manufacturing Corp. (formerly Consolidated Tool & Products Co.) has been in existence for over 18 years.

DAVID H. BROWN is now vice-president in charge of operations for New Process Gear Corp., Syracuse. He had been assistant general manager in charge of operations.

HARRY S. FORD has been appointed combustion project engineer on product design for Detroit Diesel Engine Division, GMC. He was formerly assistant forward development engineer.

KENNETH HULSING, formerly chief application engineer for the Division, has been appointed staff engineer in charge of product design and development.

HARRY E. CHESEBROUGH has been elected to the American Standards Association board of directors to serve a three-year term representing the Automobile Manufacturers Association. He is executive engineer in charge of product planning and programming with Chrysler Corp. Engineering Division.

Chesebrough was SAE vice-president representing Body Activity in 1953. He was chairman of the National Meetings Committee from 1953–1955, and served as SAE Detroit Section chairman in 1954–1955.

ERNEST R. BREECH, chairman of the board, Ford Motor Co., is one of an eight-man special citizens panel which last month gave Congress a detailed and comprehensive blueprint for the nation's peacetime atomic future. Result of a 10-month study for the Joint Senate-House Committee on Atomic Energy, the panel urged that responsibility for developing the peacetime atom be transferred to a broad partnership of Government and independent science, technology, and industry. . . . Among other things, the panel urged that the Atomic Energy Commission (of which SAE member **HAROLD S. VANCE** is now a member) abandon the concept that all nuclear information was "born classified", and should automatically be labeled secret.

Somebody Told Me

by RLSackett

HARRY KNOWLTON . . . retired a year ago as chief materials engineer, International Harvester. . . . Teaching "Metallurgy for Engineers" at Indian Technical College, Fort Wayne, Ind. and using the Iron and Steel section of the SAE Handbook as his text.

STM

M. B. "BILL" TERRY, president, American Brakeblok Division, like many another forward-looking top executive, went back to school last fall. Six weeks Business Ad at Harvard.

STM

When **ARNIE MEYER**, Heil Co. Veep, and his wife toured Europe last summer, the natives in Germany wined them and dined them and really showed them the sights. Arnie spreckened such good Deutsche that other American tourists took him for a native.

STM

1955 SAE President **ART ROSEN** is taking on more teaching duties at Stanford this spring.

STM

SAE Past-President **BARNEY ROOS**, now a private consultant, is temporarily off his tennis game. That's right, tennis. A bad eye. But it's much better. Barney, one-time member of Cornell's Big Red team, still strokes a mean game, as your editor can tell you. He plays the year around. Indoors in the winter.

STM

Dr. **CLAYT LEWIS**, Chrysler researcher, making the deluxe tour of GM's new Tech Center, came to the telephone exchange with its 21 operators. "How about an information operator," he asked the guide. "The chief operator handles that," was the answer. Just then an operator handed the C.O. a slip. She didn't know the answer. Slightly red-faced, she asked the guide. He didn't know. He asked Doc Lewis. Doc had the answer.

STM

LANS MCCLOUD, Ford Motor, is the new president of CIT (Cafeteria Institute of Technology). That's right. This CIT is 15 years old. Most of the members are SAE metallurgists. **AL HERZIG**, Climax Moly, is Poet Laureate. They have hand lettered diplomas that are classics. Outgoing president always passes out gifts. The 1955 Prexy, **FRED WALLS** International Nickel, gave all the boys sets of chisels. One year they all got shovels. Another year, brooms.

STM

ARCHIE MASON, retired chief metallurgist of GM's Ternstedt Division, yachtsman, winner of class B Chicago-Mackinac Isle race in 1932, calls his retirement his 30-year vacation. As he puts it he's been "saving his health for his old age" since he was 50. He has an article about finished under that title. His ambition is to write. His studio is his 58 ft sail boat where he drops anchor and writes. If the mood doesn't fit, he can watch the shadows in the water, drop a line overboard, or mix a drink.

WALTER E. BENJAMIN has retired from all activities with the Pierce Governor Co., Inc., Anderson, Ind.

Benjamin has been serving with Pierce Governor since 1930, when he joined the organization as a sales representative. He was a special project engineer at the time of his retirement. He has contributed several patents and has several patents pending on centrifugal governors.

R. C. BOYLE has recently been assigned to foreign operations for the International Harvester Co. and will be located at St. Dizier, France. His position there will be chief product engineer for the Compagnie Internationale des Machines Agricoles with general offices in Paris.

He has been assistant divisional chief engineer for International Harvester in Chicago.

JAY C. PATERSON has moved to the Chicago branch of International Harvester Co. as supervisor of dealer service. He has been branch manager for International Harvester in Salt Lake City, Utah.

CLIFFORD F. HOOD, president, U. S. Steel Corp., was a featured speaker at a three-day conference on "The Education of Physicians for Industry," at the Mellon Institute, Pittsburgh, Dec. 6–8. His subject was "Industry's Stake in Rising Health Standards."

THOMAS ADOLPH GOLDEN is now serving as a design engineer with Aerojet-General LRP Corp. He had been serving in the same position with Food Machinery & Chemical Corp.

S. E. DITHMER, formerly manager, Diesel locomotive products for General Motors Overseas Operations, has been named managing director of General Motors (France).

JEAN V. GIESLER, an executive vice-president of Robertshaw-Fulton Controls Co., has retired as general manager of the Fulton Sylphon Division after almost 43 years of continuous service. He will continue to serve as a consultant for the company.

FRED C. RUNFOLA is now associated with the Martin Aircraft Co., Baltimore, Md., as a weapons systems evaluation specialist in the Advanced Design Department staff group, covering Aircraft and Missiles.

Runfola was formerly with the U. S. Air Force, Air Materials Command (civilian) as an aircraft and vehicle program coordinator. Later he served as supervisory logistics officer, chief of the plans division, reporting directly to the Commanding General.

CURTIS L. MOODY, formerly factory manager of U. S. Rubber Co.'s Detroit tire plant, has been named to head the new production planning department of the tire division as production planning manager.

W. S. MOUNT, manager of the Aviation Department of Socony Mobil Oil Co., has been elected 1956 chairman of the Aviation Technical Service Committee of the Division of Marketing, American Petroleum Institute.

JAMES E. WASEM, JR. has recently been appointed supervisor of the J-79 Basic Engine and Qualification Group of J-79 Engine Evaluation with the General Electric Aircraft Gas Turbine Division.

HERBERT B. HUBBARD, previously staff assistant with United Air Lines, Inc., has become staff superintendent—applied mathematics with the company Chicago branch.

FRANK B. JOHNSON, who joined Lockheed Aircraft Corp.'s California special projects organization 10 years ago, has been appointed to head up the corporation's new Special Projects Engineering Division, Marietta, Ga.

RAY B. KALANQUIN has become chief of inspection for Convair Division, General Dynamics Corp. in the Palmdale plant. He has been inspection supervisor for the Division Plant II in San Diego.

EUGENE L. BRICKMAN has joined Anderson, Greenwood & Co., Bellaire, Texas, as a design engineer. He had been a research engineer with North American Aviation, Inc., Downey, Calif.

CLAUDE E. COX has been appointed a vice-president and director of George L. Nankervis Co. He will also continue as founder and president of Commercial Research Laboratories, Inc.

Commercial Research Laboratories, Inc. has recently become a division of the George L. Nankervis Co.

J. S. DECKER has become administrative assistant to the vice-president of Electric Auto-Lite Co. He has been head of sales engineering department of the company's Toledo operations.

ROY FRUEHAUF, president of Fruehauf Trailer Co., has predicted that "Automation's golden era—just a few years away—will raise the nation's employment to an all-time high, shorten the work week, and hike the average pay check."

Truck-trailers, already part of the automatic process, will have an even bigger role. He visions a "tremendous future" for piggybacking.

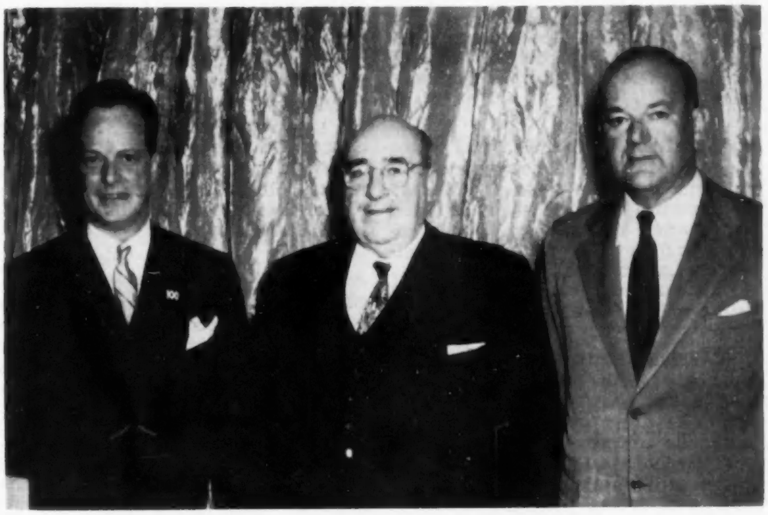
Fruehauf made his predictions at a press conference in the Park Lane Hotel, New York City.

HAROLD V. NUTT (left), new head of the Naval Engineering Experimental Station's Internal Combustion Engine Laboratory, Annapolis, receives congratulations from retiring head W. F. Joachim.

Nutt first became associated with the Experimental Station as a contract employee in 1938. After a year in diesel fuel research, he joined the permanent staff of the Internal Combustion Engine Laboratory as head of its fuel and auxiliaries branch.

In 1947 he became assistant superintendent of the Laboratory. Four years later he was selected to head the Station's Fuels and Lubricants Project which was formed at the time to coordinate and direct the Station's extensive work in those fields.

Nutt was SAE vice-president representing Passenger Car Activity in 1954.



C. R. SMITH (right), president of American Airlines, Inc., declared that never before in the nation's history have so many improvements been introduced into American travel as in the last 100 years.

Smith was a guest speaker at the transportation session of Rand McNally's "Chicago Assembly" on Jan. 6. Andrew McNally III, president of Rand McNally & Co., is at left.

Introducing Smith was **DR. ROBERT E. WILSON,** president of the Standard Oil Co. of Indiana. The session theme was "Opportunities and Responsibilities in Transportation."

ROSTER CORRECTIONS

To correct an error on page 282 of the Jan. 15 Roster Issue, SAE Journal is happy to print the following statement:

Wetmore Hodges and Associates, Inc., Redwood City, Calif., is a company having no connection whatsoever with the newly formed Locomotion Engineering, Inc. The following SAE members have been and still are employed by Wetmore Hodges and Associates, Inc.:

BARBER, J. R.—project engineer
HODGES, H. C.—resident director, Detroit Arsenal Test Operation, San Antonio, Texas
HUNDLEY, R. A.—director of engineering
MCKINLEY, D. K.—engineer
NELSON, V. T.—fleet superintendent
REED, H. R.—chief, service branch
SICKLER, R. E.—project engineer
WALLIN, C. O.—project engineer

JOHN PETER KULY is now an assistant to the plant engineer as a manufacturing supervisory trainee with Continental Can Co., Inc., Elwood, Ind.

JOHN MODELL, JR. has taken the position of staff assistant to the general manufacturing manager—Defense Operations, Studebaker-Packard Corp.

Modell had been production manager for Smith-Morris Corp., Ferndale, Mich.

EDWARD G. DINGMAN has joined Glenn L. Martin Co. as a senior materials and processes engineer. He will be concerned with the supervision and coordination of reinforced plastics activity and development in the Engineering Laboratories.

Dingman has been a senior chemist with Goodyear Aircraft Corp.

EDWIN R. BRODEN, president and director of SKF Industries, Inc., has been elected chairman of the board of Tyson Bearing Corp., a subsidiary of SKF. He replaces **RICHARD H. DeMOTT**, who has announced his resignation as chairman of the board and director of Tyson.

ROBERT J. EXTER has been appointed vice-president and director of manufacturing of Hunter Engineering Co. He had been associated with Wyman-Gordon Co. for 20 years. At the time of his move to Hunter, he was vice-president of manufacturing at Wyman-Gordon in Worcester, Mass.

ELTON S. MOYER has been appointed chief engineer in charge of the development and research program of Moraine Products Division, GMC. He joined Moraine Products in July, 1955 as assistant chief engineer.

FRANCIS J. MARKEY has been promoted to the newly created position of sales manager of automotive products for the Division. He has been assistant chief inspector since June, 1954.

THOMAS W. GREGORY has taken the position of managing director of Seaman Brothers (Amal) Pty. Ltd. in Somerset East, Cape Providence, South Africa. He had been service manager of Harrison Motors, Ltd. in Port Elizabeth, South Africa.

DAN A. KNEE has joined Esso Standard Oil Co., Charlotte, N. C. as a commercial accounts salesman. He has been serving with E. I. du Pont de Nemours & Co., Inc. as a lubricants technical service engineer in the Petroleum Laboratory.

DONALD A. BERNARDI, previously associate engineer with Glenn L. Martin Co., is now associated with Lycoming Division of Avco Mfg. Corp. as draftsman.

ROBERT H. SCHMIEL has been appointed chief engineer of the Industrial Hydraulics Division of Parker Appliance Co. He has been serving as assistant chief engineer for the Division.

JAMES H. PATRIE has become an application engineer with Worthington Corp., Denver, Colo. He has been participating in the corporation's training program.

A. G. ELLIOTT has retired from his post as executive vice chairman of the Rolls-Royce Co. after 43 years of service. His address is now "Holmwood", Quarndon, North Derby, England.

OWEN W. HALE is now assistant chief engineer of Anderson Co., Gary, Ind. He had been a sales engineer with the company in Detroit.

S. H. McALLISTER has been named director, Agricultural Research Division, Shell Development Co., Denver, Colo. He has been assistant director of research with Shell Development in Emeryville, Calif.

HARRY M. McCULLY is now teaching in the Engine Section, Product Service Department, General Motors Institute. He had formerly been service manager of Western Division, Clark Brothers Co., Olean, N. Y.

G. J. FABIAN, formerly with the Hydraulic Drives Department of Westinghouse Electric Co., is now principal mechanical engineer "B" in the Flight Research Department of Cornell Aeronautical Research Laboratory, Inc.

WILLIAM A. FURST has taken the position of senior project engineer with Consolidated Diesel Engine Corp., Stamford, Conn. He had been a design engineer with O. E. Szekely & Associates of Philadelphia.

WALTER J. PIPER is now serving with the Jet Division of Thompson Products, Inc. He had been quality control manager for Eaton Mfg. Co. Aircraft Division.

L. B. READ, formerly chief engineer of Carter Carburetion Corp., has been elected vice-president in charge of engineering for the company.

ROBERT H. PYLKAS is now with Studebaker-Packard Corp. as manager, Product Program Coordination, Corporate Product Planning. He had served as a product planning analyst with Ford Motor Co.

Pylkas has professional affiliation with the National Sales Executives Club, Detroit Sales Executives Club, Engineering Society of Detroit, and the United States Naval Academy Alumni Association.

JAMES D. RODEN is now technical assistant to the production manager of Ford Division, Ford Motor Co. He has been superintendent, major sub-assembly, Ford Division.

MILTON B. PUNNETT has joined the Research Department of United Aircraft Corp. as a research engineer. He will be concerned with instrumentation, principally on wind tunnel setups. He has been a graduate student at Cornell University.

LOUIS POLK, president, Sheffield Corp.; **JOSEPH SUNNEN,** president, Sunnen Products Co.; and **GERVAIS W. TRICHEL,** executive vice-president, Amplex Division, Chrysler Corp., are serving on the Research Fund Committee of the American Society of Tool Engineers.

ALBERT R. GRIESBACH, formerly a projects and methods engineer with Tinnerman Products, Inc., is now vice-president of The Elmer C. Cook Co., Cleveland, Ohio.

H. WARD OLANDER has joined Delta Industries, Inc., Berea, Ohio as a project engineer. He has been a research engineer with Allis-Chalmers Mfg. Co.

JOHN D. KLEIS has been appointed manager of the electrical contact division of Fansteel Metallurgical Corp. He has been serving as assistant director of research for the corporation.


Gilbert


Blanchard

JOSEPH GILBERT has been named secretary of the SAE Technical Board and manager of the Technical Committee Division at SAE headquarters. He has been assistant manager of the Publication Division and managing editor of SAE Journal.

Gilbert succeeds **DON BLANCHARD,** who has held these positions since the organization of the Technical Board 10 years ago.

The transfer of responsibilities is being made in response to Blanchard's desire for a less demanding schedule of duties. He will continue as a staff engineer in the Technical Committee Division, concentrating his work mainly on committees in the motor vehicle field which deals with problems having broad public interest, such as the Lighting Committee, the Motor Seat Belt Committee and others of similar character. He will also continue to have staff responsibility for the Society's technical cooperative relationships with such agencies as the Uniform Code Committee, the Engineering Committee of the American Association of Motor Vehicle Administration, the Engineering Advisory Committee of the Automobile Manufacturers Association, and others.

Announcing the Gilbert appointment, SAE Secretary & General Manager John A. C. Warner said: "Gilbert's nine years of widening service on the SAE headquarters staff bring him to his new responsibilities with a broad working knowledge of SAE committee operations and traditions.

"In addition to his publications experience, he has gained active knowledge of SAE committee work as our staff representative serving the Production Activity Committee—a work which he will continue. He has gained experience on general staff methods as well, as a member of the informal 'operations group' here at SAE headquarters."

Graduated from the College of the City of New York with a degree of Civil Engineer, Gilbert served as an industrial engineering officer in the AAF Air Technical Service Command in World War II. His rank was 1st Lieutenant. In that capacity he was assigned to the investigation and supervision of government expenditures for plant facilities required by AAF contractors in the Eastern District.

After joining SAE, he earned a Master of Science degree in Industrial Engineering at Columbia University. While in uniform, he also instructed officers classes in weight and balance and theory of application in the AAF Technical School at Yale University.

Obituaries

CLAUD L. STEVENS

Claud L. Stevens, Ford Motor Co. employee for 37 years, died Jan. 18 of a heart attack.

Stevens was supervisor of the Quality Control Laboratory Section, Engine and Foundry Division, at the time of his death. He had started with Ford as a night foreman in 1918. In 1927 he moved into the Metallurgical Laboratory for experimental heat treat work. From then until the present his major activities have been in the metallurgical field.

He was a member of the SAE Aircraft Engine Materials and Processes Committee. He was also a member of the Engineering Society of Detroit, the American Society for Metals, the Scottish Rite, and was a Shriner.

FREDERICK V. BOTT

Frederick V. Bott, assistant director of the General Motors Fleet Section, Detroit, died Jan. 19 of a heart attack. He was in New York attending activities connected with the opening of the General Motors Motorama.

An employee of General Motors for 30 years, Bott joined the Chevrolet Division in 1928 and remained with that Division until 1930 when he joined the Fleet Section. He had been assistant director of the Section for the past 10 years.

ELBERT L. POTTER, JR.

Elbert L. Potter, Jr., sales manager, non - automotive, Houdaille - Hershey Corp., died Oct. 16. He had served the corporation since 1948.

Potter was born in Omaha, Neb. in 1900 and attended the University of Michigan from 1921 to 1924. He received a BS in Chemical Engineering.

In 1925 he joined Hupp Motor Car Corp. as an experimental engineer. He served there until 1929, when he moved to Gabriel Co. in Cleveland. His position in the Gabriel Co. was sales engineer.

From 1934 to 1942, Potter was sales manager with Houde Engineering Corp. in Buffalo. He moved to French & Hecht Division of Kelsey-Hayes Wheel Co. for three years and then returned to Houde Engineering. Houde had become a division of Houdaille-Hershey Corp.

He became divisional sales manager for Houde Engineering Division in 1948 and took over the position of sales manager, non-automotive for Houdaille-Hershey Corp. in 1955.

WILLIAM E. KEMP

William E. Kemp (M '14) died Dec. 29. He had served on Metropolitan Section's Governing Board and had been Chairman of the Section in 1922.

When he joined SAE he was a New York City distributor for Byrne, Kingston & Co., Kokomo Brass Works, and

CONTINUED ON PAGE 98

HENRY G. BOOSKE has joined Radio Corp. of America in Lancaster, Pa. as associate engineer. He has been an experimental test engineer with Pratt & Whitney Aircraft Division, United Aircraft Corp.

LYNN L. BRADFORD is now with the U. S. Army as a 2nd Lieutenant Project Engineer in the Field Service Division at Redstone Arsenal, Huntsville, Ala.

Bradford has been an assistant project engineer in the Guided Missile Warhead Branch of U. S. Naval Ordnance Laboratory, White Oak, Silver Spring, Md.

WARD H. BRIGHAM is now affiliated with Midland Steel Products Co., Power Brake Division, Owosso, Mich. as a resident engineer. He has been with Redmond Co., Inc. of Owosso as a sales engineer.

E. N. COLE, chief engineer of Chevrolet Motor Division, General Motors Corp., was guest speaker at the Engineers' Week Inter-Society Dinner in Flint, Mich. His topic was "The Engineer's Hard Job of Making Life Easier."

CHARLES C. DEVINE is now district sales manager for the Detroit area for Western Felt Works, Acadia Synthetic Products Division. He has been district sales manager for the company.

JOHN DIETRICH has joined Chrysler Corp. as a contact engineer in the Marine and Industrial Engine Division. He has been a lubrication engineer (selling) for McColl-Frontenac Oil Co., Ltd.

You'll . . .

. . . be interested to know that

"OVER 2000 APPLICATIONS FOR MEMBERSHIP and over 400 applications for grade transfer have come up before SAE Council for consideration during 1955."

This is the report of T. B. Rendel, 1955 Membership Grading Committee Chairman, as he delivered it at the Jan. 13 Council Meeting. The report continues:

"The grade distribution of those elected was as follows: 40% elected to Member grade; 40% to Associate grade; and 20% to Junior grade."

The percentage distribution by grades of membership of the overall membership as of the end of the 1954-1955 fiscal year, Sept. 30, 1955 reads as follows: 58% are Members; 24% are Associate Members; and 18% are Junior Members.

1956 SAE National Meetings . . .

March 6-8
Passenger Car, Body, and Materials Meeting
Hotel Statler
Detroit, Mich.

March 19-21
Production Meeting and Forum
Hotel Statler, Cleveland, Ohio

April 9-12
Aeronautic Meeting, Aeronautic Production Forum, and Aircraft Engineering Display
Hotel Statler, New York, N. Y.

June 3-8
Summer Meeting
Chalfonte-Haddon Hall
Atlantic City, N. J.

August 6-8
West Coast Meeting
Mark Hopkins Hotel,
San Francisco, Calif.

September 10-13
Tractor Meeting and Production Forum
Hotel Schroeder, Milwaukee, Wis.

October 2-6
Aeronautic Meeting, Aircraft Production Forum, and Aircraft Engineering Display
Hotel Statler, Los Angeles, Calif.

October 10-12
Transportation Meeting
Hotel New Yorker
New York, New York

November 1-2
Diesel Engine
The Drake, Chicago, Ill.

November 8-9
Fuels and Lubricants Meeting
The Mayo, Tulsa, Okla.

1957

January 14-18
Annual Meeting and Engineering Display
The Sheraton-Cadillac and Statler Hotels,
Detroit, Michigan

SAE National Production Meeting and Forum

Hotel Statler | **Cleveland, Ohio** | **March 19-21, 1956**

Production Forum March 19

Gen. Chr.: **J. E. Adams,** White Motor Co.

Seven panels of specialists lead informal gatherings in interchange of information and experience on day-to-day production problems.

Luncheon: "**Atomic Energy in Your Future**" T. Keith Glennan, president, Case Institute of Technology

Production Meeting March 20

Gen. Chr.: **D. S. Kimball, Jr.,** Bendix-Westinghouse Automotive Air Brake Co.

Talk on "**How to Communicate Ideas in the Factory**" by Alex Bavelas, Massachusetts Institute of Technology

Panel: **New Developments in Free-Machining Steels**

Luncheon: "**Impressions of Russia's Productivity**" by A. C. Hall, Bendix Aviation Corp. and N. L. Bean, Ford Motor Co.

Plant Tours March 21

Morning: See the world's largest forging press rated at 50,000 tons, and others—the first installation completed under the Air Force multi-million dollar heavy-press program.

Heavy Press Plant of Aluminum Co. of America

Afternoon: Travel through the widest, continuous Strip Mill in the world. It produces hot and cold sheet up to 91 inches wide.

98-Inch Strip Mill of Republic Steel Corp.

SAE National Aeronautic Meeting, Aeronautic Production Forum, and Aircraft Engineering Display

Hotel Statler | **New York, N. Y.** | **April 9-12, 1956**

Aeronautic Production Forum April 9

Gen. Chr.: **M. F. McCammon**, Bendix Aviation Corp.

Seven separate informal gatherings to exchange information on vital aeronautic production problems—"Programming for Product Availability and Reliability." Each group will have a panel of experts available all day to answer questions.

Aeronautic Meeting April 10-12

Gen Chr.: **R. Dixon Speas**, aviation consultant, La Guardia Airport

Two panel discussions: "**Breaking the Time Barrier Between Design and Production**" and "**Fuels and Fuel Systems for Turbine Transports**"

30 papers of importance in the aeronautic field

Three luncheons, including **presentation of the Wright Brothers Award and the Laura Taber Barbour Air Safety Award**

SAE Sky-Ball Dinner-Dance, 7:30 P.M., April 12

Aircraft Engineering Display April 9-12

Gen. Chr.: **H. R. Harris,** Aviation Financial Services, Inc.

April 9-11—9:00 A.M. to 9:00 P.M.
April 12—9:00 A.M. to 12:30 P.M.

70 Up-to-the-Minute Aeronautical Developments

SECTIONS

MARCH 1956

Sections Procedure Booklet To Undergo Efficiency Study

T. R. Thoren, vice-chairman of the SAE Sections Committee for 1956 has been named to head a subcommittee to review the Sections Procedure booklet and to make recommendations for revisions. Named to serve with Thoren on the subcommittee are J. A. Nelson, W. F. Ford, and R. K. Hirchert.

The objectives of this subcommittee, Thoren reports, are:

1. To provide, in Section Procedure, a document which will help Section and Group Governing Boards to administer Section and Group activities in keeping with SAE policies and procedures and to attain the objective set forth in the Section philosophy;

2. To guide each officer and committee chairman in the performance of his duties, and

3. To present ideas which have proven successful in Section and Group operations.

SAN DIEGO

W. F. Bunsen, Field Editor

Old Timer's Night was celebrated at the Section January meeting. A 35-year Membership Certificate was presented to Merl Ruskin Wolfard, who came to San Diego from New England Section. He served as New England Section chairman in 1925–1926. In tune with the theme, experts explored the differences in problems, techniques, equipment, and adventures of old-time test pilots with those of today.

Mid-Michigan

G. W. Colby, Field Editor

Mid-Michigan Students Are Busy SAE Personnel

SAE's large Student Enrollment from Mid-Michigan Section's Student Branches is a hustling influence in Section activity. Student activity and Section activity have been carefully integrated for mutual benefit and enjoyment.

In the geographical area of the Mid-Michigan Section, two schools have active SAE Student Branches. These are General Motors Institute, with an engineering enrollment of 1900, and Michigan State University, with an engineering enrollment of 2000. Interest in SAE has been consistent through the years in both schools with a student group at G.M.I. since 1932 and at M.S.U. since 1947.

The Mid-Michigan Section has encouraged student participation in Society activities by sponsoring a student paper contest and offering dinner tickets for regular meetings at a reduced rate. Since two national meetings each year are held in Detroit, it is possible to encourage students to attend these meetings also.

SAE members have worked with the Student Branches by assisting in planning student activities and by appearing as speakers on technical subjects.

At General Motors Institute, an objective each year is to provide an opportunity for students to obtain information regarding different activities from those in the plants where they are employed in their cooperative program. Meetings such as the discussion of the XP-300 with C. A. Chayne, the Chevrolet Corvette with Maurice Olley, the GT-301 gas turbine engine for bus and Firebird I by John C. Coleman are examples of recent student meetings.

The program at G.M.I. for this year began with a membership drive and technical meeting at which activities of the General Motors Proving Ground were described by T. M. Fisher. Several dinner meetings and trips through automotive plants are also planned for the year.

As a result of such interesting programs with an active group of Student Branch Officers and an interested Faculty Adviser, enrollment in the G.M.I. Student Branch has been consistently highest among all Student Branches in the U.S.A. Present enrollment is 330 students.

At Michigan State, the SAE Student

An Option . . .

"Any member residing outside Section territory, upon written request for assignment to membership in a given Section may be so assigned.

"Such a member can select only one Section."

The above information (pertinent to the 5% of SAE members who live outside Section or Group territory) is printed at the request of SAE Council.

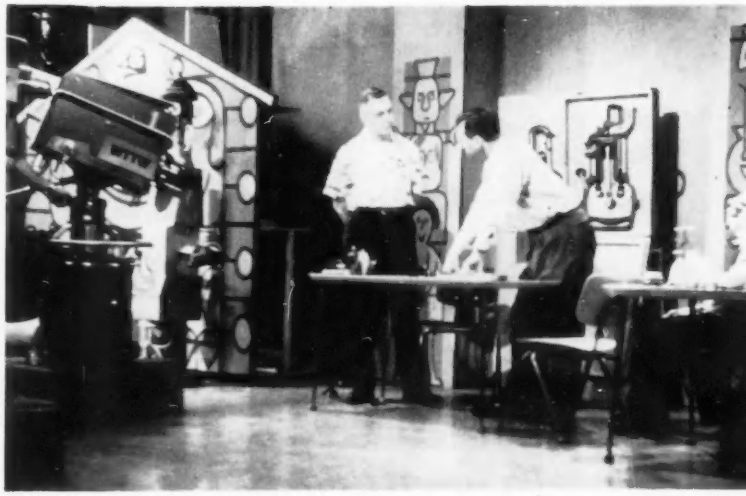
Requests for assignment to a specific Section or Group should be addressed to Sections Department at SAE Headquarters.

Branch has been active in promoting interest in the automotive industry amongst the people who attend the University's Engineering Exposition each spring. As one of the participating member groups of the Engineering Council, the SAE Student Branch has joined other student groups in sponsoring the Engineering Exposition, and in assisting with the many promotional and display activities which this Exposition entails. Students have created each year a fifteen minute TV show over the M.S.U. station to boost SAE to the viewers.

Two years ago as a publicity stunt for the Exposition, the Engineering Council sponsored a midget car race around the campus drive. The SAE Student Branch built and entered a car, along with six other student organizations, and emerged champions in two four-mile races.

In addition to its Engineering Council activities, the M.S.U. SAE Student Branch sponsors plant visits for interested students, and obtains outstanding technical speakers and popular films for the engineering student body. Present SAE student enrollment is 36 students.

Student Committee Chairman E. K. Harris, in cooperation with Faculty Advisers K. F. Lehman of G.M.I. and L. L. Otto of M.S.U. feel that a contributing feature of the Mid-Michigan Student Program has been the offering of dinner tickets for regular meetings to students at reduced rate. This has done much to acquaint students with the Society's activities and has resulted in a large number of students retaining their SAE affiliation after graduation.



Chicago Section Chairman Jack Nelson (left) gives SAE a plug on television show, "Totem Club," with his two sons (far right) and Don Clayton, producer.

New England

George T. Brown, Field Editor

Airlines at Logan Airport Welcome Aero Meeting Notices

In its drive to increase interest in many phases of the automotive field, New England Section has carried out a plan to notify airline companies at Logan International Airport in Boston of all Section aero meetings.

Flyers have been composed to go out with Section meeting announcements for posting in company offices. Also follow-up telephone calls are made prior to each meeting to all interested parties.

Aeronautics is one phase of the automotive field that has not received deserved attention in New England, according to the Section Governing Board. Results of this drive indicate that the Section's efforts are very much appreciated at Logan Airport.

CHICAGO

P. P. Polko, Field Editor

Chairman Nelson & Sons Salute SAE on Chicago TV

Chicago educational TV station WTTW featured Section Chairman Jack A. Nelson and his two sons on a half hour show entitled "Automobiles, Past, Present, and Future," Jan. 2. And SAE profited.

The show is a daily feature called, "Totem Club," produced by Don Clayton for children from eight to thirteen years of age. Leading characters in the presentation were Nelson's sons, Tom, aged eight, and Norman, aged eleven.

Chairman Nelson provided the program introduction, giving SAE a plug in the process. He brought SAE in as an important cog in the wheel of progress, particularly regarding safety.

His sons carried through this theme of safety in progress, entering the picture with an electric powered model Ford Thunderbird complete with safety belt and crash helmet.

Tom then explained the operation of a two stroke cycle engine, using a cutaway model. Norman followed with the demonstration of a four stroke cycle model.

The diesel viewpoint was provided by father Nelson. An aerosol bomb contributed the fuel spray. A cork gun demonstrated low and high compression. A "four candlepower" Swedish Angel Chime displayed gas turbine action.

Chicago Section gives Chairman Nelson, and his two young sons, its seal of approval for the great job they did. Here is a chairman who believes in awaking folks to the SAE—early.

Awaking Chicago to SAE Placement Services

—A. R. Hempe

Demand for engineering talent in the Chicago area exceeds the known available supply of experienced engineers. This is the problem confronting the Chicago Section Placement Committee.

Efforts of the placement Committee, headed by A. R. Hempe, have been directed toward acquainting members of the Section and its Student Branches of the available services.

It has become a regular practice at monthly Section meetings to post positions available and men available on the Section bulletin board. The information is obtained from the monthly SAE Placement Bulletins. The idea is to focus attention on the Placement Service within SAE both from the employers' standpoint and from the members' standpoint.

A special drive has been made to acquaint the SAE Enrolled Students at Aeronautical University and the Illinois Institute of Technology with opportunities in the service. There is a two-fold objective in this program. The first, of course, is to make possible a greater exposure of these students to available jobs in industry. Secondly, we aim to bring them into closer contact with SAE and encourage their continuing activity after graduation.

PITTSBURGH

W. C. Weltman, Jr., Field Editor

Keen Competition Means Pittsburgh "Student Night"

Competition requires cooperation. And both are vital to SAE operation. So, Pittsburgh Section uses "Student Night" to illustrate this concept to students.

The Section regular meeting night in April each year is set aside for student technical paper competition. Competitors are provided by SAE Student Branches at Carnegie Institute of Technology and the University of Pittsburgh.

The April meeting was chosen by the Section for this event to avoid conflicting with registration or semester and final examinations.

Arrangements for the competition are worked out by the Section Student Committee chairman in cooperation with Department Heads of both schools, Faculty Advisers, and Student Branch chairmen.

Each Branch then holds its own contest or elimination. The papers do not have to be original, but they must be related to the automotive field. The program can also be varied to include a four member panel discussion or debate on a related subject.

At the final Student Night Competition, an award is presented to each participant; a cash award or gift of technical books goes to the winner; and a plaque is given to the winning school. This plaque exhibits the SAE emblem and a metal tag engraved with the winner's name. The school retains it until the next Student Night.

Keen competition and many excellent programs have made this meeting a favorite to students and Section members as well. The Section is proud to include the competing students, their Faculty Advisers, and the school Department Heads as special guests at the Speakers' Table.

The 1955 event, held on April 26, coupled the student competition with the Section Golden Anniversary Dinner. **R. L. Kirkpatrick,** 1955 chairman of the SAE Student Committee gave us a short talk. **Hollister Moore,** manager of SAE Sections and Membership Division, also attended and was introduced.

The papers—excellent ones—covered "Problems of High Altitude Flight," "Maintenance Problems of Military Aircraft," "Advances Toward the Ideal Automobile Transmission," and "The Automobile Gas Turbine." Contestants were: **Ralph Klug** and **David Gish,** University of Pittsburgh; and **James Nixon** and **Thomas Rodwick,** the Carnegie Institute of Technology. The winning paper by Gish was "Maintenance Problems of Military Aircraft."

Col. Willard F. Rockwell topped off the meeting with his Golden Anniversary talk, "Looking Backward and Forward from SAE's Golden Anniversary."

1. Competitors in the 1955 **Pittsburgh Section** Student Technical Paper contest were (left to right): **Ralph Klug,** Carnegie Institute of Technology; **David Gish** (the winner), University of Pittsburgh; **James Nixon,** University of Pittsburgh; and **Thomas Rodwick,** Carnegie Institute.

2. Honored guests at the 1955 Student Night Speakers' Table included (left to right): **Prof. William Stokey,** SAE Faculty Adviser, Carnegie Institute; Prof. W. M. Rohrer, SAE Faculty Adviser, University of Pittsburgh; **Prof. N. Lewis Buck,** head, University of Pittsburgh Department of Mechanical Engineering; **Prof. D. W. VerPlank,** head, Carnegie Institute Department of Mechanical Engineering; **E. P. White,** 1954–1955 Pittsburgh Section Student Committee Chairman; **R. L. Kirkpatrick,** 1955 SAE Student Committee Chairman and a past chairman of Pittsburgh Section; and **H. K. Siefers,** 1954–1955 Pittsburgh Section chairman.

Metropolitan

Leslie Peat, Field Editor

Twenty-eight Metropolitan Section members were honored at the January 5 Dinner Meeting when they received certificates for having been SAE members for 25 years or more.

Among the veteran members of the Society were two who yield to no one for their vision of yesteryear or their vigor of today. They were Fifty-year-members **William P. Kennedy**, Met Section's first chairman, and **Joseph Tracy**, one of the world's first race car drivers, both of whom are Life Members, '05.

Bill and Cap are consulting engineers.

Ten 35-year members were among those honored for their long membership in SAE. They were:

Charles O. Bech, vice-president Publication Services, Inc.; **Gordon Brown**, vice-president of the Bakelite Co. Division of Union Carbide & Carbon Co.; **Gustaf Carvelli**, Wright Aeronautical Division, Curtiss-Wright Corp.; **John F. Creamer**, chairman and president of Wheels Incorporated, a former chairman of Met Section; **Livingston Disbrow, Harcourt C. Drake**, Sperry Products, Inc.; **James B. Funk**, Champion Spark Plug Co.; **Edward H. Kocher**, Bijur Lubricant Corp.; **Raymond P. Lansing**, vice-president and group executive, Bendix Aviation Corp.; and **Norman G. Shidle**, editor of *SAE Journal* and a former chairman of the SAE Philadelphia Section.

Sixteen men, SAE members for 25 years, who were honored by the Section were:

Waldo H. Blackmer, manufacturers representative; **Chester C. DePew**, consulting engineer; **Earl V. Farrar**, assistant chief engineer, Wright Aeronautical Division, Curtiss-Wright Corp.; **Clayton Farris**, president, Tructor Corp. and a former Met Section chairman; **Robert T. Haslam**, a director of Esso Standard Oil Co.; **Otto C. W. Henze**, consulting engineer; **Daniel G. Jewett**, G. Krueger Brewing Co.; and **Hudson W. Kellogg**, Ethyl Corp.

Other 25-year members honored were:

George Krieger, Ethyl Corp.; **William W. Lowe**, Cities Service Petroleum, Inc.; **C. R. Maxon**, New Jersey Zinc Co.; **Harry Price**, patent attorney; **Harold J. Ritter**, president, Harold J. Ritter Co.; **Thomas B. Roscoe**, Curtiss-Wright Corp., Propeller Division; **George W. Smith, Jr.**, chairman of the board of DeLaval Steam Turbine Co. and its Canadian subsidiary; and **Dr. Guido Soria**, consulting engineer with offices in New York City and Torino, Italy.

Western Michigan

W. A. MacLaurin, Field Editor

With the hope of becoming better acquainted with other active engineering groups in Michigan, a joint meeting was held on March 6 with the Aero Club of Michigan. **SAE Past-President A. T. Colwell** was guest speaker.

Central Illinois

Harlan Banister, Field Editor

Attendance Mounting At Earthmoving Industry Conf.

Registered attendance at the Central Illinois Section Earthmoving Industry Conference grew from 596 in April, 1950 to nearly 1200 in 1955.

This continuing increase in registered attendance reflects the widespread interest in a technical meeting designed to meet the needs of the earthmoving industry and associated fields.

Plans underway for many months are near completion. They promise to produce a technical meeting of unrivaled significance to the industry.

The Conference, to be held in the Pere Marquette Hotel, Peoria, Ill., April 3-4, 1956, is now the fourth largest SAE technical meeting.

At right on page 89 is a listing of the program offered by the SAE Earthmoving Industry Conference to be held April 3-4 in the Hotel Pere Marquette, Peoria, Illinois.

The SAE Earthmoving Industry Conference Committee pauses for its photograph at a recent committee meeting. (Left to right) are: **J. S. Smith**, arrangements chairman; **R. K. Polak**, finance chairman; **R. J. Furstoss**, general chairman; **F. N. Norris**, housing chairman; **M. W. Clark**, secretary; **T. M. Fahnestock**, program chairman; and **I. R. Lamport**, publicity chairman. Members of the committee not present when the picture was taken are: **G. W. Eger**, treasurer; and **R. V. Larson**, Central Illinois Section chairman.

Earthmoving Industry Conference Program

TUESDAY, APRIL 3

9:30 AM Welcome by General Chairman, **R. J. Furstoss**

Keynote Address—**Dr. Harold Vagtborg**, president, Southwest Research Institute

Technical Chairman—**Cloyd W. Richards**, LeTourneau-Westinghouse Co.

"Designing for Maintenance—Crawler Tractors"
Harry M. Bidwell, assistant chief engineer, Allis-Chalmers Mfg. Co.

"Designing for Serviceability"
Frank A. Grooss, assistant to vice-president, Caterpillar Tractor Co.

1:30 PM Technical Chairman—**Douglas W. Erskine**, Allis-Chalmers Mfg. Co.

"Conventional Drive Lines as Applied to Earthmoving Machinery"
John Borland, chief engineer, Wisconsin Axle Division, Rockwell Spring & Axle Co.

"What's Behind the Trend to Torqmatic Drives"
R. M. Schaefer & H. C. Kirtland, Allison Division, General Motors Corp.

"Tournamatic Drives for Tractors"
John M. Hyler, chief engineer, Tractor Section, LeTourneau-Westinghouse Co.

"Planet Power Steering for Crawler Tractors"
Phillip J. Sperry, chief engineer, Industrial Power Division, International Harvester Co.

6:30 PM Banquet
Speaker—**Tom Collins**
"The Ape and the Shotgun"

WEDNESDAY, APRIL 4

9:00 AM Technical Chairman—**Otto A. Bossart**, Young Radiator Co.

"Cooling Problems Due to Mounted Equipment"
Ernest H. Panthofer, vice-president, Perfex Corp.

"The Use of Heavy Equipment in Logging"
Gordon A. MacGregor, MacGregor Triangle Construction Co.

1:30 PM Technical Chairman—**Professor Ellis Danner**, Civil Engineering Department, University of Illinois

"Rebuilding Ruined Roads With Machines"
Rufus S. Kirk, county engineer, Sedgwick County, Kansas

"From the Ground Up"
George A. Bowie, Department of Public Relations, Firestone Tire and Rubber Co.

No. California

L. J. Abell, Field Editor

Section meeting announcements have been composed to include announcements of Section and Division activities. Combining the notices is one measure the Section has taken to cut operating expenses. Each announcement contains a returnable postcard to be torn out and sent in to the secretary to indicate the member's attendance plans at the Section or Division meetings.

The Coffee Speaker has become an institution of Northern California Section's dinner meetings. The speaker delivers a short talk between dessert and the regular meeting. So far the Section has been successful in obtaining very good local talent.

Coffee Speaker for the Jan. 25 Northern California Section meeting was E. S. Moore, California State Automobile Association.

No. California Section

South Bay Division

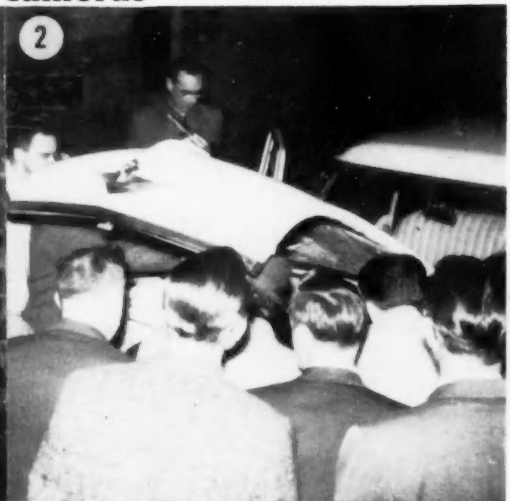
Spreading the Good Word About SAE Placement Service

—G. R. Picolet

South Bay Division Placement Chairman C. O. Wallin has gone to work for SAE Placement Service, contacting local companies, colleges, and universities for available opportunities.

He went to the local Chamber of

From Section Cameras



Commerce for lists of manufacturing companies in the region, then culled out those concerned with positions related to automotive engineering.

To all these related industries he mailed a form letter inviting their participation in the Placement Service, described by enclosed pamphlets and forms.

Now plans are being formulated to assist students in the local colleges and universities in obtaining summer employment.

MONTREAL

A. A. Larkin, Field Editor

A draw was called at the Section Annual Student Night technical paper competition. Contestants **G. T. Connery** of McGill University and **Louis Courville** of Ecole Polytechnique received cash awards for their work.

J. T. Dyment, Section Speakers Committee chairman, then presented his views on "Engineering Education."

1. Technical Speaker for the **Northern California Section** Jan. 25 meeting was **I. T. Rosenlund,** chief of automotive technical service, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

2. Fuel injection car for du Pont tests, the 1954 Lincoln Capri, is investigated by interested **Northern California Section** members after Rosenlund's description.

3. **J. F. Millan** (right), **Central Illinois Section** technical chairman for the Jan. 30 meeting, introduces Speaker **F. R. Holliday,** head, stress analysis laboratory, Chrysler Corp. Holliday spoke to the Section on "Chrysler Die Cast Aluminum Torque Converter Housings."

4. Speakers at the **Cleveland Section** January meeting pose for a Journal photograph. They are (left to right): **S. R. Rouze,** General Motors Corp.; **R. H. Albrecht,** Standard Oil Co. (Ohio), who presented the paper, "Stop Sludge and Go Clean"; and **Kent Hyatt,** E. I. du Pont de Nemours & Co., Inc., co-author of the paper.

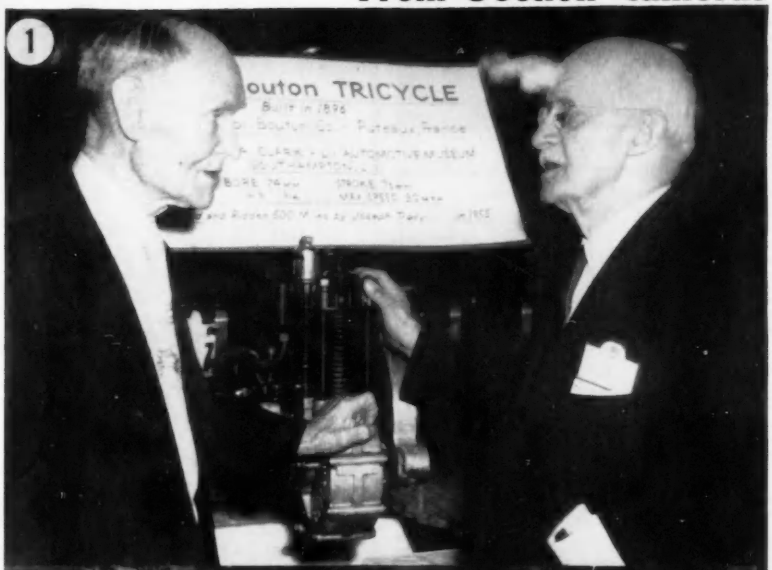
So. New England

S. L. Leavitt, Field Editor

Yale University Student Branch has started a program of week night movies in addition to regular activities. The plan has so far met with gratifying results.

Monthly activities of the Branch have included a recent field trip to Kaman Aircraft Corp. in Bloomfield, Conn. Also a meeting on fuels was held in December with the ASME student branch.

From Section Cameras



1. **Joseph Tracy** (left) shows **William P. Kennedy** the DeDion Bouton tricycle which he restored. The machine was built by the famous pioneer motor vehicle builder in 1896 in Puteaux, France, and was loaned for the Jan. 5 dinner-meeting of **Metropolitan Section** by **Henry Austin Clark, Jr.,** owner of the Long Island Automotive Museum, Southampton, L. I. Last year Tracy rode the tricycle 500 miles. Both of these men are Founder Members of SAE, and Kennedy was the first Chairman of Met Section.

2. **William M. Kissam** (left), vice-chairman for Transportation & Maintenance of **Met Section,** joins **Richard D. Hornidge,** Baldwin-Hamilton-Lima Corp., who described electronic weighing of trucks and tractors at the Jan. 5 Dinner-Meeting. Kissam is with Tide Water Associated Oil Co. as automotive engineer.

3. A record attendance was present at the **Northern California Section South Bay Division** Feb. 7 meeting to hear Detroit speaker **Thomas E. Dolan** of Detroit Transmission Division, GMC. Members and invited guests, who included local truck fleet operators, were privileged to be presented the technical paper "The General Motors Twin Hydramatic Truck Transmission."

4. **New England Section Chairman J. Roy Smith** (right) discusses points of the paper, "'More Strength—Per Pound—Per Dollar'; A Formula for Measuring Modern Truck Body Material," with the author, **Paul R. Hafer,** president, Boyertown Auto Body Works. Hafer was guest speaker at the Section Bus & Truck Activity Meeting, Dec. 6.

KANSAS CITY

H. H. Hart, Field Editor

"I want my son to attend a school that has an SAE Student Branch!"

SAE Vice-President J. D. Redding made this announcement at a recent Kansas City Section Governing Board meeting. Informal discussion brought out the following reasons:

"I want my son to have every opportunity to become a successful engineer. I want him to get an early start in the activities of a professional society of his chosen field. Through Student Branch and Section meetings he will be able to make acquaintance with senior members of industry and perhaps meet his future boss."

ST. LOUIS

F. H. Roever, Field Editor

March Meeting Brings Student Night Celebration

Parks College campus will be the site of the St. Louis Section Student Night festivities March 21. Once each year the Section devotes its meeting to the students of the Parks College Student Branch and the Missouri School of Mines Student Branch in Rolla, Miss.

The program for this year will be similar to those of the past with three students from each Student Branch presenting technical papers before the Section members.

Prizes include cash awards, SAE Student Enrollments, and a team prize, the "SAE Banner." As a team the three men from each school compete for the possession of the banner for another year. At present it is in the possession of the Parks group.

It is expected that a large number of students from both schools will attend, along with St. Louis Section members and school Faculty members.

The day's activities will include guided tours of the Parks campus for all interested.

Preparations for this popular Section meeting are handled chiefly by the Student Branches with the assistance of the Faculty Advisers of the two schools. They are also assisted by the chairman of St. Louis Section Student Activity Committee and committee members.

The site for the meeting is alternated each year.

Section

ALBERTA

March 16 . . . Al San Club

BUFFALO

March 27 . . . **M. J. Kittler**, executive vice-president, Holley Carburetor Co., Detroit, Mich.; **I. T. Rosenlund**, manager, Automotive Technical Service, E. I. du Pont de Nemours & Co., Inc. Petroleum Laboratory, Deepwater, N. J.; and **R. Carley**, Esso Standard Oil Co., Detroit, Mich. —Symposium on "Carburetion vs Fuel Injection." Hotel Sheraton. Dinner 7:00 p.m. Meeting 8:00 p.m.

CANADIAN

March 21 . . . **1956 SAE President George A. Delaney**.—"Designing an Automobile." Royal York Hotel.

CENTRAL ILLINOIS

March 19 . . . Student Meeting. Hotel Pere Marquette.

April 3–4 . . . Earthmoving Industry Conference. Hotel Pere Marquette.

CHICAGO

March 15 . . . **John D. Caplan**, Research Staff of Research Laboratories Division, GMC, Detroit. —"1956 Engines and Their Fuels." Knickerbocker Hotel, Chicago. Dinner 6:45 p.m. Meeting 8:00 p.m. Special Features: Social Half-Hour sponsored by Gulf Oil Corp., Pure Oil Co., Shell Oil Co., Sinclair Refining Co.

SOUTH BEND DIVISION.

March 19

April 10 . . . Aircraft Meeting. Knickerbocker Hotel.

CLEVELAND

April 10 . . . Akron-Canton Meeting. **Professor Ackoff**, Case Institute of Technology.—"Operations Research." Speaker-Sponsor: **C. G. Troxler**, vice-president of production, The Hoover Co. Mayflower Hotel, Akron.

DETROIT

March 19 . . . Junior Activity Panel Meeting. **W. E. McCollough**, Holley Carburetor Co.; **D. H. Silvern**, Continental Aviation & Engineering Corp.; **William Carter**, American Bosch Arma Corp.—"More HP Per Cu. In." Moderator: **R. J. Stark**, Eaton Manufacturing Co. Dinner Speaker: **Lt. Lester Coykendall**, Michigan State Police. Rackham Educational Memorial. Dinner 6:30 p.m. Banquet Hall. Meeting 8:00 p.m. Small Auditorium.

March 26 . . . **Peter DePaolo**, Ford Motor Co.; **Mauri Rose**, GMC.—"Stock Car Racing."—Moderator: **E. N. Cole**, Chevrolet Motor Division, GMC. Consultants: **W. E. Burnett**, Ford Motor Co.; **R. M. Rodger**, Chrysler Corp. Dinner Speaker: **T. L. Blakeman**, Regional Planning Commission, Detroit Metropolitan Area. Rackham Educational Memorial. Dinner 6:30 p.m. Banquet Hall. Meeting 8:00 p.m. Large Auditorium.

INDIANA

March 15 . . . **A. R. Graham** & **D. G. Elliott**, Purdue University, School of Mechanical Engineering.—"Propulsion Problems of the Satellite Vehicle." Marott Hotel, Indianapolis. Dinner 7:00 p.m. Meeting 8:00 p.m. Special Features: Social Half-Hour 6:30 p.m.

KANSAS CITY

April 2 . . . Automotive Gas Turbines Meeting. **Lamont Eltinge**, Research Department, Standard Oil Co. of Indiana.

METROPOLITAN

March 14 . . . Aeronautic Activity Meeting. **Dale O. Moeller**, chief engineer, Stratos Division, Fairchild Engine & Airplane Corp.—"Advent of Freon Cooling in Jet Powered Aircraft." Garden City Hotel, Garden City, L. I. Meeting 7:45 p.m.

April 5 . . . Diesel Engine Dinner Meeting. **R. Tom Sawyer**, manager, research, Alco Products Inc., Schenectady, N. Y.—"Future of Railroad Motive Power." The Brass Rail Restaurant, Fifth Avenue & 43rd Street, New York. Cocktail Hour 5:30 p.m. Dinner 6:30 p.m. Meeting 7:45 p.m.

Meetings

MILWAUKEE

April 6 . . . Donald R. Diggs, supervisor, Engine Test, Petroleum Lab., E. I. du Pont de Nemours & Co., Wilmington, Del.—"Fuel Requirements of Tomorrow's Engine." Milwaukee Athletic Club. Dinner 6:30 p.m. Meeting 8:00 p.m.

PITTSBURGH

March 27 . . . W. J. Pelizzoni, manager, Testing Laboratory, Mack Manufacturing Corp., Plainfield, N. J.—"The Mack End 673 Diesel Engine." Dinner 6:00 p.m., Hotel Webster Hall. Meeting 8:00 p.m. Mellon Institute.

MID-MICHIGAN

March 12 . . . Darrel R. Sand, senior project engineer, Detroit Transmission Division, GMC, Willow Run, Mich.—"Whirlaway Transmission." Elks Club, Flint, Mich. Dinner 6:30 p.m. Meeting 7:30 p.m.

MOHAWK-HUDSON

March 21 . . . Future Trends in Aircraft Power Plants. Crossroads Restaurant, Latham, N. Y.
April 11 . . . Latest Development in Fuels and Lubricants. Crossroads Restaurant, Latham, N. Y.

MONTREAL

March 21 . . . Carl Larsen, chief sales engineer, Canadair, Montreal. Mount Royal Hotel. Dinner 6:15 p.m. Meeting 8:00 p.m. Joint Meeting with Canadian Aeronautical Institute.

NEW ENGLAND

April 3 . . . George F. Dixon, president, Dart Truck Co., Kansas City, Mo.—"Custom Building in the Off-Highway Equipment Field." M.I.T. Faculty Club. Dinner 6:45 p.m. Meeting 8:00 p.m.

NORTHERN CALIFORNIA

March 28 . . . Diesel Meeting. Engineers Club, San Francisco. Dinner 6:30 p.m. Meeting 8:00 p.m.

NORTHWEST

April 13 . . . Section-Student Meeting. Presentation of three Student Papers. University of Washington, Seattle. Dinner 7:00 p.m. Meeting 7:45 p.m.

PHILADELPHIA

March 14 . . . A Representative of The Allison Division, GMC.—"Fuel & Lubricant Requirements of Commercial Gas Turbine Aircraft." The Engineers Club. Dinner 6:30 p.m. Meeting 7:45 p.m.

ST. LOUIS

March 21 . . . Annual Student Night with Technical Papers by Parks College and Missouri School of Mines & Metallurgy. Students competing for Casn Awards—SAE memberships and the "SAE BANNER" presented to winning team annually. Dinner served in Parks College Cafeteria 7:00 p.m. Meeting 8:00 p.m. Special Features: Tours of College Campus—4 to 6 p.m.

SAN DIEGO

April 4

SOUTHERN CALIFORNIA

March 12 . . . Truck and Bus Dinner Meeting.
April 9 . . . Aircraft Production Panel Meeting.

SOUTHERN NEW ENGLAND

April 12 . . . E. Katzenberger, chief development engineer, Sikorsky Aircraft Co., Bridgeport, Conn.—"Performance of Helicopters as Related to Heliport Problems." Yale University. Dinner 6:30 p.m. Meeting 7:30 p.m.

TWIN CITY
April 11

WESTERN MICHIGAN

April 12 . . . Clyde E. Evenson, automotive service engineer, Shell Oil Co., N. Y.—"On the Spot Testing of Used Lubricating Oils." Doo Drop Inn, Muskegon, Mich. Dinner 7:00 p.m. Meeting 8:00 p.m. Special Features: This meeting is of primary interest to fleet men.

CINCINNATI

H. E. Pitzer, Field Editor

—R. H. Metzler

University of Cincinnati Student Branch followed up their tour of the Cincinnati Ford Transmission Plant on Feb. 10 with another tour on Feb. 15. This time they visited the General Electric Gas Turbine Division.

This occasion marked the first time that restrictions have been lifted to allow a tour of the plant. In conjunction with the ASME Student Branch at the University, the group inspected some of the new developments in high temperature and high velocity research.

ALBERTA

William Fairhead, Field Editor

Traveler Hannam Relates Highlights of Annual Meeting

Acquainting Alberta Group members with the doings at SAE Annual Meeting in Detroit Jan. 9–13 was the assignment of William Hannam at the Group's Jan. 20 meeting.

His visit was directed toward determining the level of Alberta Group meetings and speakers in relation to the sessions he attended at the meeting. His conclusions read as follows:

"Our own Group meetings indicate that our Governing Board is providing materials and speakers of a high caliber. Subjects are well presented and are valuable contributions to the advancement of our engineering knowledge."

He added, "The courtesy and hospitality shown to me in Detroit were very much appreciated by a Canadian visitor."

SAE Student Branch Outside Of Section Territory

University of Miami Student Branch was unintentionally slighted in the Society's Annual Report which was published in the January 1956 SAE Journal. We failed to mention that this fast-growing Student Branch was one of those to receive its charter during 1955.

TECHNICAL COMMITTEE *Progress*

ASA Probes Standards For Nuclear Energy Field

THE American Standards Association will form a planning committee to recommend appropriate standardization in the field of nuclear energy. That was the unanimous recommendation of a conference called by ASA in Washington on December 8, and attended by representatives of more than 150 trade associations, professional societies, government agencies and industrial organizations.

Two points stood out in the discussion of the problem:

1. There's an urgent need for standards, particularly those related to safety, in the atomic energy field.
2. The actual standardizing job should be turned over to existing standards-making agencies who already are engaged in atomic work, or who have a natural interest and a desire to participate in this activity.

The need for standards in the nuclear energy field is now becoming critical, one engineer noted. That's because the activity is in transition from research to the application stage. More and more technical men are thirsting for engineering information. Standards provide a good way of sharing this knowledge.

The note of urgency was sounded by varied interests. Those getting ready to build and operate nuclear powerplants pointed to a state of confusion because of inadequate standards to work with. For instance, the existing ASME code for pressure piping was reported to be unsuited to the handling of corrosive fluids used in the atomic field. State agencies feel they need standards as guides in both enacting legislation and Workmen's Compensation.

A government contractor pointed out that the atomic industry is the safest industrial activity in this country. The industry is still, and will continue to be, under close government supervision; but now that private industry is getting into "atomics" on its own, industry must write its own rules for handling and operating nuclear programs.

Several atomic standards programs already are under way, it was brought out. The groups handling them wish to continue, and eventually expand these activities. For instance, ASTM has developed several test and materials specifications in the field. It considers radiation an environmental condition. ASME has a subcommittee under its Boiler Code Committee working on nuclear aspects.

Dr. A. V. Astin, director of the National Bureau of Standards, reported that the NBS has been active for over 25 years on the National Committee for Radiation Protection. NBS also is sponsor of ASA Sectional Committee Z54—Industrial Radiation Protection.

The ASA Planning Committee must move ahead rapidly on its assigned responsibility, Dr. Astin urged. Not only is the work urgent, but there is only a limited number of engineers and scientists competent to develop standards in this field. Their time is precious, and it must be used effectively.

A. S. Johnson, chairman of the ASA Standards Council and chairman of the Conference, advised how the Committee would be developed and would probably operate. He plans to consult with interested ASA member bodies and Standards Boards in selecting a committee of workable size, composed of knowledgeable men. He expects that the Planning Committee, in staking out areas of nuclear standards areas, would probably divide the problem into two aspects: (1) the human side, or protection of personnel, and (2) materials and mechanical equipment.

Johnson visualizes the possibility of ASA setting up a Nuclear Standards Board to supervise and administer the broad, implicit activities in this area. That's because atomic standards may be well outside the confines of existing Standards Boards.

ASA is a federation of about 110 trade associations and professional societies. It does not develop standards. Its basic function is: When a standard is proposed as an American Standard ASA determines whether the standard represents a concensus of those substantially concerned.

1956 SAE Technical Board

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Aero Materials Specs Reviewed by Industry

DRAFTS of fifty-one SAE Aeronautical Materials Specifications are currently being circulated to industry for comment and criticism by the SAE Aeronautical Materials Specifications Division.

Sixteen specifications have been approved recently by the SAE Technical Board.

Copies of all of these specifications are available for review from the SAE Aeronautical Department, 29 West 39 Street, New York 18, N. Y.

The specifications under review are:

- AMS 2201C — Tolerances, Aluminum and Aluminum Alloy Bar, Rod, Shapes, and Wire, Rolled or Drawn;
- AMS 2202B — Tolerances, Aluminum and Aluminum Alloy Sheet and Plate;
- AMS 2203C — Tolerances, Aluminum Alloy Drawn Tubing;
- AMS 2205D — Tolerances, Aluminum and Magnesium Alloy Extrusions;
- AMS 2232C — Tolerances, Carbon Steel Sheet, Strip, and Plate;
- AMS 2252A—Tolerances, Alloy Steel Sheet, Strip, and Plate;
- AMS 2262B—Tolerances, Nickel and Nickel Alloy Sheet, Strip, and Plate;
- AMS 2403D—Nickel Plating;
- AMS 3204D—Synthetic Rubber, Low Temperature Resistant (25-35), Chloroprene Type;
- AMS 3205D—Synthetic Rubber, Low Temperature Resistant (45-55), Chloroprene Type;
- AMS 3237A—Synthetic Rubber, Phosphate Ester Resistant, Butyl Type (35-45);
- AMS 3238A—Synthetic Rubber, Phosphate Ester Resistant, Butyl Type (65-75);
- AMS 3239A—Synthetic Rubber, Phosphate Ester Resistant, Butyl Type (85-95);
- AMS 3345—Silicone Rubber (1000 psi) (45-55);
- AMS 3346—Silicone Rubber (1000 psi) (55-65);
- AMS 3356—Silicone Rubber, Lubricating Oil and Compression Set Resistant Electrical Grade (55-65);
- AMS 3605D—Plastic Sheet, Post-Forming, Cotton Fabric Reinforced Phenol-Formaldehyde;
- AMS 3615B—Plastic Tubing, Cotton Fabric Reinforced Phenol-Formaldehyde;
- AMS 41XX—Aluminum Alloy Forgings 2.2Cu-1.6Mg-1.1Fe-1.1Ni (2618-T6);
- AMS 4230C—Aluminum Alloy Castings, Sand, 4.5Cu (195-T4) Solution Treated;
- AMS 4286A—Aluminum Alloy Castings, Permanent Mold 7Si - 0.3Mg (356-T51);
- AMS 5201—Magnetic Alloy Sheet and Strip Nickel-Iron Alloy, Annealed;
- AMS 52XX—Magnetic Alloy Sheet and Strip Nickel-Iron Alloy ½ Hard;
- AMS 5380C—Alloy Castings, Precision Investment, Corrosion and Heat Resistant, Cobalt Base — 26Cr-15Ni-6Mo;
- AMS 5613D—Steel, Corrosion and Moderate Heat Resistant, 12.5Cr (SAE 51410);
- AMS 5680C—Steel Wire, Corrosion and Heat Resistant, 18Cr-11Ni (Cb+Ta);
- AMS 5681B — Welding Electrodes, Coated, Steel, Corrosion and Heat Resistant, 19Cr-10Ni-(Cb+Ta);
- AMS 5787 — Welding Electrodes, Coated, Alloy, Corrosion and Heat Resistant, Nickel Base—4Cr-24.5Mo-5.5Fe;
- AMS 7263—Rings, Packing, Synthetic Rubber, Phosphate Ester Hydraulic Fluid Resistant (85-95), (Butyl Type);
- AMS 7277—Rings, Sealing, Synthetic Rubber, Phosphate Ester Hydraulic Fluid Resistant (70-85), (Butyl type);
- AMS 72XX—Ring Sealing, Synthetic Rubber, Oil Resistant (80-95);
- AMS 7XXX—Rings, Sealing, Tubular Metal;
- AMS —— Steel Tubing, Welded, Corrosion and Heat Resistant 18Cr-10Ni-Ti (SAE 30321), Thin Wall;
- AMS —— Steel Tubing, Welded, Corrosion and Heat Resistant 18Cr-11Ni-(Cb+Ta) (SAE 30347), Thin Wall;
- AMS —— Synthetic Rubber—Flame Resistant (50-60);
- AMS —— Synthetic Rubber—Flame Resistant (70-80);
- AMS —— Electrolytic Treatment for Magnesium Base Alloys, (Alkaline Type);
- AMS —— Electrolytic Treatment for Magnesium Base Alloys, Acid Type;
- AMS —— Silicon Bronze, 92Cu-3.2Si-2.8Zn-1.5Fe;
- AMS —— Wire Gold Alloy;
- AMS —— Flexible Polyurethane Foam, Open Cell, Medium Flexibility, 2.5 Lb Per Cu Ft;
- AMS —— Alloy Corrosion and Heat Resistant, Nickel Base—5Cr-24.5Mo-5.5Fe;
- AMS —— Lead Counterweight Alloy (6% Antimony);
- AMS —— Bolts and Screws, Steel, Low Alloy Heat Resistant, Normalized and Tempered—Roll Threaded;
- AMS —— Plating Aluminum for Solderability;
- AMS —— Magnesium Alloy Castings, Sand—3.3Th-0.8Zr (HK31A-T6), Solution and Precipitation Treated;
- AMS —— Welding Electrodes, Coated, Steel, Corrosion Resistant 13Cr;
- AMS —— Steel Wire, Corrosion Resistant 13Cr;
- AMS —— Steel Sheet and Strip, Corrosion and Moderate Heat Resistant, 13Cr-2Ni-3W;
- AMS —— Hard Coating Treatment of Aluminum Alloys;
- AMS —— Steel, Corrosion and Heat Resistant 15Cr-26Ni-1.3Mo-2.1Ti-0.3V, 150,000 psi Tensile;

16 Specifications that have been approved recently by the SAE Technical Board.

- AMS 2675A—Nickel Alloy Brazing;
- AMS 3212H—Synthetic Rubber;
- AMS 3214F—Synthetic Rubber
- AMS 3590—Plastic Sheet, Copper Faced, Paper Reinforced;
- AMS 3601—Plastic Sheet, Copper Faced, Glass Fabric Reinforced;
- AMS 4120D—Aluminum Alloy Bars, Rods and Wire, Rolled or Drawn;
- AMS 4135H—Aluminum Alloy Forgings;
- AMS 4139F—Aluminum Alloy Forgings;
- AMS 4152F—Aluminum Alloy Extrusions;
- AMS 4352A—Magnesium Alloy Extrusions;
- AMS 4890—Copper-Beryllium Alloy Castings, Precision Investment;
- AMS 5573A—Steel Tubing, Seamless, Corrosion and Heat Resistant;
- AMS 5591C—Steel Tubing, Seamless, Corrosion Resistant;
- AMS 5690E—Steel Wire, Corrosion and Heat Resistant;
- AMS 5738—Steel, Corrosion Resistant;
- AMS 6427A—Steel;

Kohr Heads '56 Technical Board

R. F. KOHR, director, general engineering, Ford Motor Co., has been appointed chairman of the 1956 SAE Technical Board by SAE President G. A. Delaney. Seven new members also were appointed to the Technical Board for three-year terms.

The new Board members, whose terms expire at the end of 1958, are: C. F. Arnold, chief engineer, Cadillac Motor Division, GMC; Trevor Davidson, chief engineer, research and development, Bucyrus-Erie Co.; W. H. Graves, vice-president, director of engineering, Studebaker-Packard Co.; W. M. Holaday, Department of Defense, Research and Development; A. E. W. Johnson, vice-president, engineering, International Harvester Co.; C. L. Sadler, manager, Sundstrand Aviation Division, Sundstrand Machine Tool Co.; and D. D. Streid, manager, engineering jet engine dept., General Electric Co.

Board members whose terms expired at the end of 1955 are: D. P. Barnard, Standard Oil Co. (Indiana); G. E. Burks, Caterpillar Tractor Co.; C. A. Chayne, General Motors Co., who was Board Chairman in 1955; H. E. Churchill, Studebaker-Packard Corp.; E. G. Haven, General Electric Co.; C. E. Mines, Allison Division, GMC; and B. G. VanZee, Minneapolis Moline Co.

Kohr is a graduate of University of Michigan, from which he received a B.S.M.E. degree in 1917. He served as an officer in World War I in the Engineering Corps and Tank Corps. From 1920 to 1926, he served with the Automotive Power Plant Section, Bureau of Standards, and the Engine Section, Bureau of Aeronautics.

From 1926 until his association with Ford following World War II, Kohr served with Studebaker, Bendix, Asbestos Mfg. Co., Packard, and General Motors. He came to Ford as assistant director of research, was promoted to director of research in 1948, and to executive engineer, General Engineering, in 1951.

Kohr was SAE Vice-President for Passenger Car in 1955. He is a Past Chairman of the SAE Washington Section. In 1955, his first year as a member of the Technical Board, he was Sponsor of a number of technical committees.

New Chairman

R. F. Kohr

Arnold

Davidson

Graves

Holaday

Johnson

Sadler

Streid

Obituaries

Continued from Page 81

Kokomo Electric Co. of Kokomo, Ind. He handled their eastern and foreign distribution. In 1928 he moved his offices to Detroit, distributing for Kingston Products Corp. of Kokomo.

Kingston Products Corp. named him district sales manager in 1929 and then made him vice-president in charge of engineering in 1931.

His last work before retirement was inventing, developing, and marketing a compensating spring speed governor for truck engines.

Kemp retired from active service and from SAE participation in 1936. He moved to Orlando, Fla., where he opened a citrus grove.

H. WILLIAM OVERMAN

H. William Overman, director of sales for Brooks Equipment Division, Borg-Warner Corp., died in September. He had joined Brooks Equipment in late June.

Overman started work in 1924 as an apprentice tool maker at Detroit Seamless Tube Mill. In 1925 he went to work in the Engineering Department of the Continental Motors Corp. handling engineering specifications.

In 1929 he began association with Standard Motor Truck Co., but moved to Buda Engine Co. of Harvey, Ill. in 1930 as sales engineer.

From 1936 to 1945, Overman served with Ferodo & Asbestos, Inc., New Brunswick, N. J. He started as sales and service engineer and rose to consulting engineer.

He then moved to the American Pulley Co. and served as manager of the Materials Handling Division and Defense Contract Division from 1950 to 1955.

EARLE H. GOULD

Earle H. Gould, section supervisor, Ford Motor Co. Lincoln-Mercury Division, died Oct. 28.

Gould started in industry in 1926 as a tracer for Studebaker Corp.'s Engineering Department. Since then he has served in layout and engineering with companies such as Chandler Cleveland Motor Car Corp., Hupp Motor Car Corp., Chrysler Motor Corp., Packard Motor Car Corp., Fisher Body Division of GMC, Willys Overland Motors, Inc., and Ford Motor Co.

He started with Ford as a senior designer in 1951 and became section supervisor for the Lincoln-Mercury Division in 1952.

FRANK E. PAYNE

Frank E. Payne, chairman of the board and co-founder of Crane Packing Co., died Nov. 20 at his home in Glencoe, Ill. The 72-year old industrialist had been ill for a long time.

Payne was a nationally recognized authority in the products his company produces, namely: mechanical packings, mechanical seals, Teflon products, lapping machines, and pipe joint compounds. He invented some of the most widely used packings in the marine field and general industry, and early foresaw the advantages of mechanical seals.

Starting his career as a pump salesman, Payne gained much of the thorough first-hand knowledge that led to his part in the founding of Crane Packing Co. He became president in 1917 and for 34 years guided the firm in its growth. In 1951 he took up the duties of chairman of the board.

Payne was a member of the American Society of Mechanical Engineers, Alumni Organization of Massachusetts Institute of Technology (Class of 1905), and Sigma Alpha Epsilon Fraternity.

Precision Machining Calls for More Skill

Based on paper by

T. CONWAY

Lycoming-Spencer Div., Avco Mfg. Co.

CONCURRENT with the move to eliminate the human element in production, greater demands have been placed upon the individual operator due to the complexity of automation in machine tools. The sole exception is found where machines are almost entirely automatic and require only manual feeding and ejection. In comparatively short-run shops the burden falls upon well-trained operators using standard machines which are kept in perfect condition to produce.

Although industry has become highly specialized as contrasted with the time when both apprentices and machinists learned to handle all types of equipment, the learning process must continue. Even among trade skills such as tool-making, men now specialize in grinding, turning, milling, and boring, and industry is being run on the basis of such specialization.

The situation calls for continuous development of competent operators. They are now in short supply and spread so thin that their effectiveness is greatly diminished.

(Paper "Machining Techniques of Precision Machined Parts" was presented at SAE Wichita Section, Nov. 13, 1954. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Test Car Functions As Stress Detective

Based on paper by

LUDVIG PETERSEN

Electro-Motive Division, GMC

THE development of a locomotive structure used to call for a great deal of theoretical work and relatively little testing. Today the procedure is just the opposite, with testing being devoted to determining the stresses due to a specified load and to ascertaining the amplitude and frequency of the loads. This requires field work. To accomplish it Electro-Motive developed and built a test car of which one half is devoted to instrumentation and the other half to living quarters for the test crew.

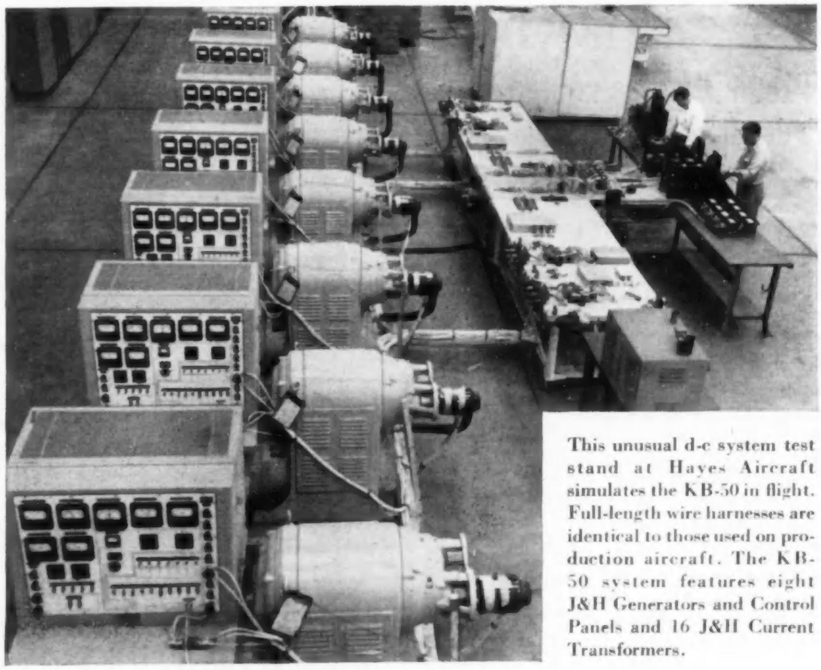
One difficulty in the use of all instruments lies in being unable to forecast when a certain event will take place. It may be theorized as to when a certain member will meet a maximum strain, but there lacks assurance that the worst conditions have been recorded. Accordingly a selective counter was designed and built to overcome this disability.

If the amplitude and frequency of the stress in a certain member is sought, all that is required is to apply a strain gage bridge to the member, run the output into the selective counter, balance the circuit, and let the counter function continuously during the run. At the end of the run the counters will show how many times the stress reached certain preset levels.

This selective counter has demonstrated its usefulness as a monitor on many occasions as the following example will testify:

A certain strut in a new model had broken several times without any apparent good reason since it was thought

1
2
3
4
5
6
7



This unusual d-c system test stand at Hayes Aircraft simulates the KB-50 in flight. Full-length wire harnesses are identical to those used on production aircraft. The KB-50 system features eight J&H Generators and Control Panels and 16 J&H Current Transformers.

8 Jack & Heintz Generators paralleled in unique d-c system!

. . . engineers achieve 78% more power for KB-50

The KB-50 will have tremendous refueling capacity. Plans call for fueling of three planes simultaneously.

Jack & Heintz G23 Generator

Rating—amp	400
Voltage—d-c	30
Speed Range—thousand rpm	3.8-8
Weight—lb	67
Dimensions—inches	
Over-all Length (from mounting flange)	13 31/32
Over-all Diameter	8
Bolt Circle Diameter	5
Spline, Pitch Diam	.8
Air Inlet Conn., OD	3
Cfm of Air at 6" H_2O & 6000 rpm	165
Rotation as Viewed from end Opposite Flange	CW

In converting the Boeing B-50 Superfort into the KB-50 mid-air refueling tanker, a substantial power boost was needed to drive the array of rapid-transfer fuel pumps honeycombed throughout the plane.

The approach lay in developing a new higher rated generator or in paralleling eight available 400-amp machines.

The Jack & Heintz G23 d-c Generator proved to be the answer. Rugged enough to withstand the high vibration characteristics in the KB-50, this generator required only a specially machined housing and a modified mounting flange.

Through the use of the G23, Hayes and Jack & Heintz engineers have achieved a power supply of 3200 amps in the same available space once yielding a maximum of 1800 amps. The unprecedented paralleling of eight generators has been test-proved completely reliable.

Also available is a modified G23 with an increased rating of 450 amps, which is ideally suited to airline applications.

For complete information, write Jack & Heintz, Inc., 17638 Broadway, Cleveland 1, Ohio. Export Dept.: 13 E. 40th St., New York 16, N. Y.

JACK & HEINTZ *Rotomotive* AIRCRAFT EQUIPMENT

to be free of any appreciable stress. So a strain gage was placed on the strut while other tests were being run.

No stresses were reported by the counter after several days of running. Finally the locomotive and test car were cut off the train to be taken down a siding for refueling. The siding had poor track with many ups and downs in the individual rails. Suddenly some counts appeared on the highest level. On coming to a stop, the strain gage bridge was so badly out of balance that blame was put upon the instrument.

An oscillograph record on the return trip proved the instrument to be all right. The strut became rapidly overloaded when the car body was twisted substantially out of normal. With this knowledge engineers overcame the trouble by rearranging a few pieces of equipment. (Paper "Field Testing of Diesel Locomotives for Strain and Performance" was presented at SAE Annual Meeting, Detroit, Jan. 10, 1956. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Fires and Explosions Quenched at Very Start

Based on paper by

GEORGE GRABOWSKI

Simmonds Aerocessories, Inc.

MODERN aircraft fire- and explosion-suppression systems work this way: An ignition-source detector and a frangible capsule of extinguishing fluid are placed in the volume to be protected. When ignition occurs, the detector senses the explosion and allows electrical current to flow to a detonator which explodes the capsule, releasing the extinguishing fluid.

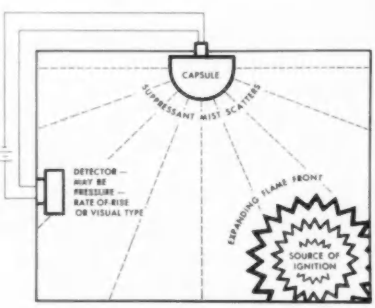


Fig. 1—System consists basically of a detector and a capsule of extinguishant. Capsule includes a detonator capable of being triggered by the detector.

Fig. 1 shows the system schematically.

Fig. 2 shows what happens to pressure within the volume when the system suppresses a potential explosion. The entire operation takes place in a fraction of a second.

The detector must act fast. To meet all requirements, two types of detectors have been developed. One is the rate-of-pressure-rise type, used to detect low-energy explosions. The other is a visual detector capable of "seeing" any explosion throughout the entire flammability range. (Paper "Developments in Explosion and Fire Suppression Techniques" was presented at SAE Metropolitan Section, New York, Dec. 14, 1954. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

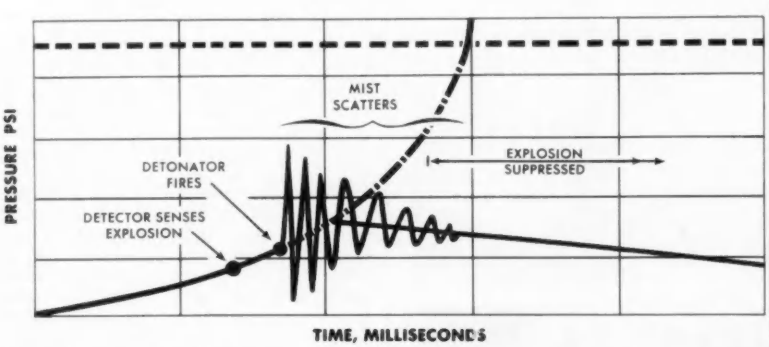


Fig. 2—Explosion-suppression system acts fast to quench an explosion before pressures build up to dangerous level.

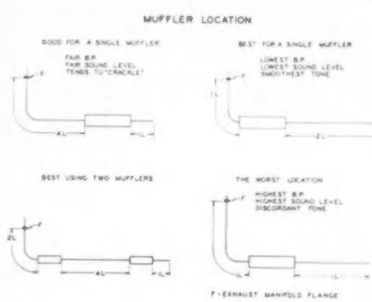
Efficacy of Muffler Depends on Positioning

Based on paper by

LEINO H. BILLEY

Donaldson Co., Inc.

Fig. 1—The location of a muffler in the exahust system is more important than is generally realized. The most effective location is the 1-2 position for a single muffler, or the 2-4-1 position if two mufflers are used. The least effective position is midway (or just beyond) between the exhaust manifold flange and the end of the exhaust pipe. (Paper "Development Engineering and Application to Muffler Manufacture for Heavy-Duty Engines" was presented at SAE Western Michigan Section, Nov. 2, 1954. It is available in full in multilith form from SAE Special Publications Department. Price 35¢ to members, 60¢ to nonmembers.)



LPG Sales Are Ever-Rising

Excerpt from paper by

J. E. GLIDEWELL

Hall-Scott Motors Co.

SALES of LP gases in the United States have been rising steadily each year. This is also true for that percentage of LPG used in internal-combustion engines except for 1948 and 1949.

During this period there was somewhat of a slump, because the price had been increased unrealistically. After this condition was corrected and a drive was put on to use LPG in farm equipment, the sales curve ascended much more rapidly in succeeding years.

There seems to be plenty of LPG available and, as distribution becomes more widely spread geographically, it should be used more and more as internal-combustion-engine fuel.

Texas now uses the largest amount

of LPG for engine fuel, followed, in order, by California, Illinois, Oklahoma, New Mexico, Louisiana, Arkansas, Kansas, Mississippi, and Arizona.

(Paper, "Use of LPG in Truck Engines," was presented before SAE Northern California Section's South Bay Division, Los Altos, Calif., Dec. 6, 1955. This paper is a revised version of an earlier paper by the same author, "Engines to Digest the Vitamin-Enriched Fuel—Elpeegee," published in SAE Transactions, Vol. 61, 1953, pp. 131–141.)

Host of Additives Developed for Modern Oils

Based on paper by

ULRIC B. BRAY

Bray Chemical Co. and Bray Oil Co.

A VARIETY of additives is being used to give lubricants qualities not otherwise obtainable. Most important among them are:

1. Oiliness agents.
2. Film strength agents.
3. Pour-point depressants.
4. Viscosity index improvers.
5. Oxidation inhibitors.
6. Detergents.
7. Rust preventives.
8. Antifoam agents.

Oiliness Agents

Oiliness agents date back to 1926. Despite this fact, oiliness is still considered the most fugitive and difficult quality of the lubricant to evaluate. That is, the effectiveness of an additive in improving oiliness is not easily proved or disproved. Properly run tests indicate, however, that oiliness is not just a slick story.

Compounds giving the best evidence of imparting additional oiliness generally contain oxygen, preferably in the groups C = O or P = O as in soaps and esters of fatty acids; soaps of sulfuric acids; and esters of phosphorus and phosphoric acids.

Film Strength Agents

A few years later, the increased film strength or load-carrying ability imparted by small additions of sulfur, chlorine, and phosphorus was demonstrated.

This type of film strength is probably the result of an antiwelding property of the additive. It may or may not be associated with increased oiliness.

The need for antiwelding property

increased as surface hardness and tensile strength of surface material increased. Hypoid gear sets constitute an outstanding example of where anti-welding is essential.

Pour-Point Depressants

Pour-point depressants reduce the temperature at which residual wax causes the oil to set.

In 1932 a condensation product of naphthalene (moth balls) and paraffin wax—called Paraflow—was synthesized for use as a pour depressant. It does not keep the wax in solution, but alters the size and shape of the wax crystals so that gelling or setting does not occur until a lower temperature is reached.

Oil-soluble forms of poly-methacrylates give pour-point lowering in small doses and V. I. improvement as well in larger doses.

Viscosity Index Improvers

About 1933 polymers of butene were developed that would both thicken an oil and give it a viscosity-temperature slope more nearly approaching—or even surpassing—that of Pennsylvania oil of the same viscosity as the thickened oil.

During the last few years a modified form of Lucite or Plexiglas called Acryloid has been developed, which permits even greater improvements in V.I., but its chemical stability under some conditions may be inferior to that of polybutene. A styrene-type polymer called Santodex is perhaps the most economical V.I. improver for a moderate increase, but it may not be sufficiently stable for the use intended.

The intelligent selection of mineral oil stock and the proper use of V.I. improvers has made possible the production of satisfactory oils for special needs that could never be met with any straight mineral oils now known.

Oxidation Inhibitors

When the public started driving cars having the so-called "alloy bearings," the use of oxidation inhibitors became a necessity with many mineral oils. Instead of only aiming to reduce sludge formation, the oil producer now had to prevent bearing corrosion by preventing the oxidation of the oil to give organic acids.

There are three main classes of oxidation inhibitors: phenolic, sulfur-containing, and phosphorus-containing compounds.

As a rule, the more highly refined a mineral oil is, the better it responds to oxidation inhibitors. Thus, the best practice is not to use oxidation inhibitors as a substitute for good refining, but as a supplementary means of achieving a degree of stability beyond the range of any uncompounded oil.

Detergents

The development of detergents to prevent ring sticking, reduce engine wear, and improve engine cleanliness

dates back to 1935. Lubrication difficulties were threatening to kill, or at least severely handicap, the development of the diesel engine in this country. The oil industry found, however, that the addition of 1–2% of an oil-soluble metal soap to the oil practically eliminated ring sticking, reduced wear by 75%, and gave diesel engines cleaner insides than most gasoline engines have.

When these oils were simply added to straight mineral oils, rapid oxidation of the oil occurred, which meant frequent drains. Also, these oils were unsafe with the "alloy" bearings.

The practical answer was found to be to add to a suitable mineral oil both a detergent and an oxidation inhibitor. Only oils having this type of compounding have been able to meet MIL-O-2104 specification requirements.

Rust Preventives

For years, many investigators have claimed that ring and cylinder-wall wear is largely the result of microscopic rusting when the cylinder walls are below the dew point of the combustion gases in the clyinder. Recent data indicate that heavy-duty and rust-preventive oils meeting U. S. Army Specifications 2-126 give less wear under cold-running conditions.

When the rust-preventive property is obtained through the use of a suitable calcium or barium sulfonate, the oil has the added advantage of exceptional detergency and ability to offset the ill effects of low-grade fuels.

Antifoam Agents

Foaming of crankcase oil never became a problem until the use of crankcase scavenging pumps that continually pull air along with the oil. Also, many of the best compounding formulas tend to increase the foaming tendency. Consequently, antifoam requirements were incorporated in U. S. Army Specification 2-104.

The most satisfactory antifoam agent seems to be a silicone compound. The proper silicone is so effective that as little as one part per million parts of oil is often sufficient. No other property of the oil need be affected.

(Paper, "Development and Use of Additives in Lubricating Oils," was presented at a Seminar on Fuels & Lubricants, Los Angeles, April 4, 1955. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Favors Reed Valve For Two-Cycle Engines

Based on paper by

S. D. POLLOW

Power Products Corp.

THERE are several methods of admitting the fuel-air mixture from the carburetor to the crankcase in two-cycle engines. There are the third port system, the rotary valve, the poppet valve, and the reed valve. For larger engines, particularly in the diesel field, blower scavenging is the system employed. We use the reed valve, considering it to be the most desirable for all phases and speeds of operation.

The reed valve is located at the base of the crankcase (Fig. 1). In this schematic sectional view of a typical two-cycle engine, the basic parts are seen to be the crankshaft, connecting rod, and piston. (In this particular design the piston has a baffle.) This mechanism is enclosed in a crankcase and a cylinder. The cylinder has an exhaust port and a transfer, or intake port, and a passage from the crankcase to the transfer port. The reed valve allows gases to enter the crankcase and also keeps them from escaping.

Two versions of the reed plate are shown in Fig. 2. The low-speed type reveals the exposed reed; the high-speed version has reed stops. The reed plates are of a die cast aluminum alloy. The reeds are made of Swedish spring steel 0.004 in. thick. They are very free and flexible and will open or close with the slightest pressure change. The stops are used only in extremely high-speed engines. The opening of the reed itself must be restricted for high-speed operation. Otherwise it would open further than necessary and tend to impair high-speed performance, and it would also tend to bend excessively.

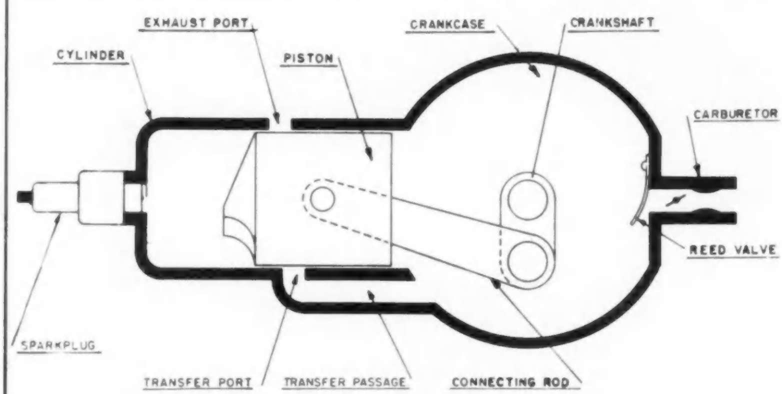


Fig. 1—Schematic view of a typical two-cycle engine showing location of the reed valve at base of crankcase. This valve remains open during the out-stroke when intake and compression occur, and is closed during the in-stroke when explosion and exhaust take place.

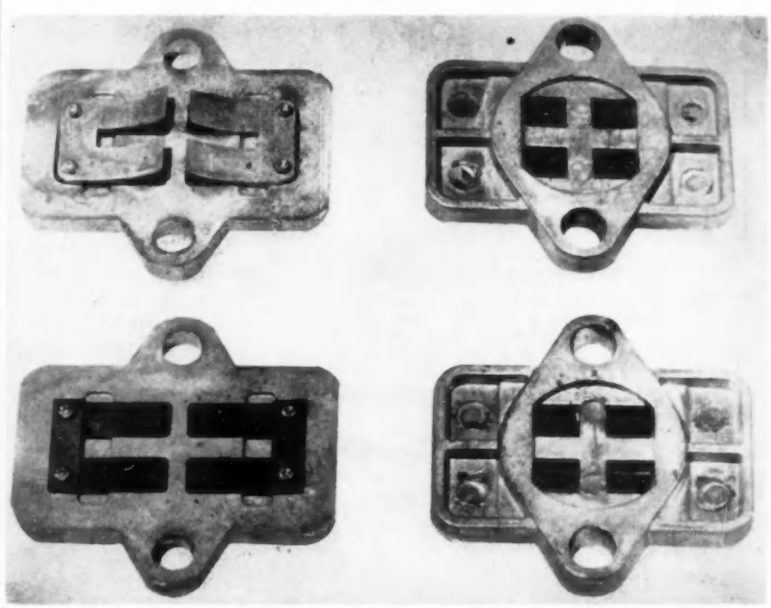


Fig. 2—Here are two types of reed plates. The low-speed version shows the exposed reed; the high-speed version has reed stops to restrict the opening of the reed itself. The reeds are highly flexible and will open or close with the slightest pressure change.

The reeds are secured to the plate by cast projections from the plate itself, utilizing a stamped bar in one case and a reed stop in the other as a hold down over the fixed ends of the reeds. These projections are pressed to form rivet heads. It is necessary to exercise close control of the alloy constituents of this material since the rivet projections must be soft and ductile enough to form heads without crumbling or breaking during the assembly operation. (Paper "The Growth of the Two Cycle Engine" was presented at SAE Southern New England Section, Nov. 3, 1954. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Production Control Aids Reaching of Goals

Based on paper by

P. A. CHRISTENSON

Square D Co.

PRODUCTION control may be defined as a systematic procedure for coordinating all the elements of production. An ideal system should exercise control over materials, methods, machines, manpower, tooling, scheduling, dispatching, and expediting or follow-up,

Experts on the Production Control Panel were

Panel Leader

B. C. Bugbee
The Falk Corp.

Panel Secretary

P. A. Christenson
Square D Co.

Panel Members

D. E. Beaton
Twin Disc Clutch Co.

F. E. Drake
Kearney and Trecker Corp.

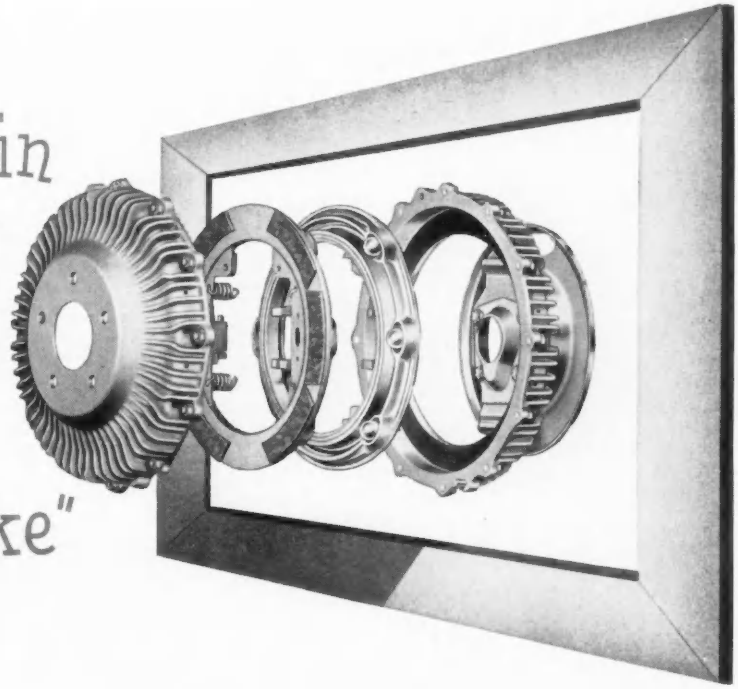
Gary Elshoff
Harnischfeger Corp.

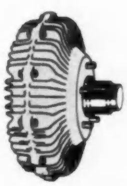
E. D. Scheele
Marquette University

Arthur Sternberg
Clearing Machine Corp.

Ist das nicht ein safer brake?

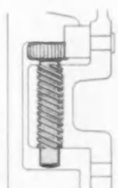
"Ja, das ist ein safer brake"



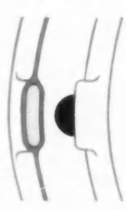


Is this not a housing better?
Yes, this is a housing better.
Aluminum made—
Gets heat away quick—no fade.

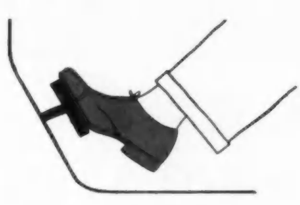
Is this not a lining better?
Yes, this is a lining better.
High deceleration rate, stops straight
Any speed or vehicle weight.



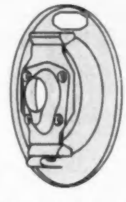
Is this not automatic, too?
Yes, this is automatic, too.
Self-adjusting screw keeps brake true
Safer for you and children, too.



Is this not self-energized?
Yes, this is self-energized.
You start it—momentum parts it
Ball and ramp is stopping champ.



Is this not a pedal predictable?
Yes, this is a pedal predictable.
Secret ensconced in ball and ramp response
To your braking wants.



Is this not a plate so still?
Yes, this is a plate so still.
Torque it takes—with housing mates
For splash-proof brakes.

It is ready, it is safer, it should be adopted now—Auto Specialties' Double-Disc Brake.

AUTO SPECIALTIES MFG. CO., INC.

Saint Joseph, Michigan

Plants also at Benton Harbor and Hartford, Michigan and Windsor, Ontario, Canada
Manufacturing for the automotive and farm machinery industries since 1908.

as well as provide the means for corrective action.

There are three essentials for any control system. They are:

1. It must be so placed that it has sufficient authority and responsibility to accomplish its designated job.

2. A staff relationship with the organization must be maintained continuously.

3. Top management must support it.

A good sales forecast is the heart of a production control system because it facilitates proper planning. Forecasts are being used for (1) planning inventory requirements and guiding purchasing, (2) advance determination of machine and manpower requirements, and (3) developing expense budgets. All company departments should be given an opportunity to review forecasts.

Business machines are being used more and more in control work. They enable a large volume of source data to be digested quickly so that facts will be available for decision making. Prime factors in deciding whether or not to use business machines are the accuracy of the source material and the expense of collecting and handling it.

The job of production control is made easier when manufacturing facilities are flexible. The ability to hold machine shop schedules and smooth the work flow is greatly enhanced by eliminating the conditions which hamper flexibility, such as short runs of repair parts. One concern has solved this by making the production of repair parts a separate function carried on by a separate division.

(This article is based on the secretary's report of Panel on Production Control and Its Effect on Manufacturing held as part of the Production Forum at the SAE Golden Anniversary Tractor Meeting, Milwaukee, Sept. 12, 1955. It is available in full together with six other reports as SP-312, from SAE Special Publications Department. Price: $1.50 to members, $3.00 to nonmembers.)

Design Simplifies Convair Maintenance

Based on paper by

J. J. ALKAZIN

and

J. C. HOOVER

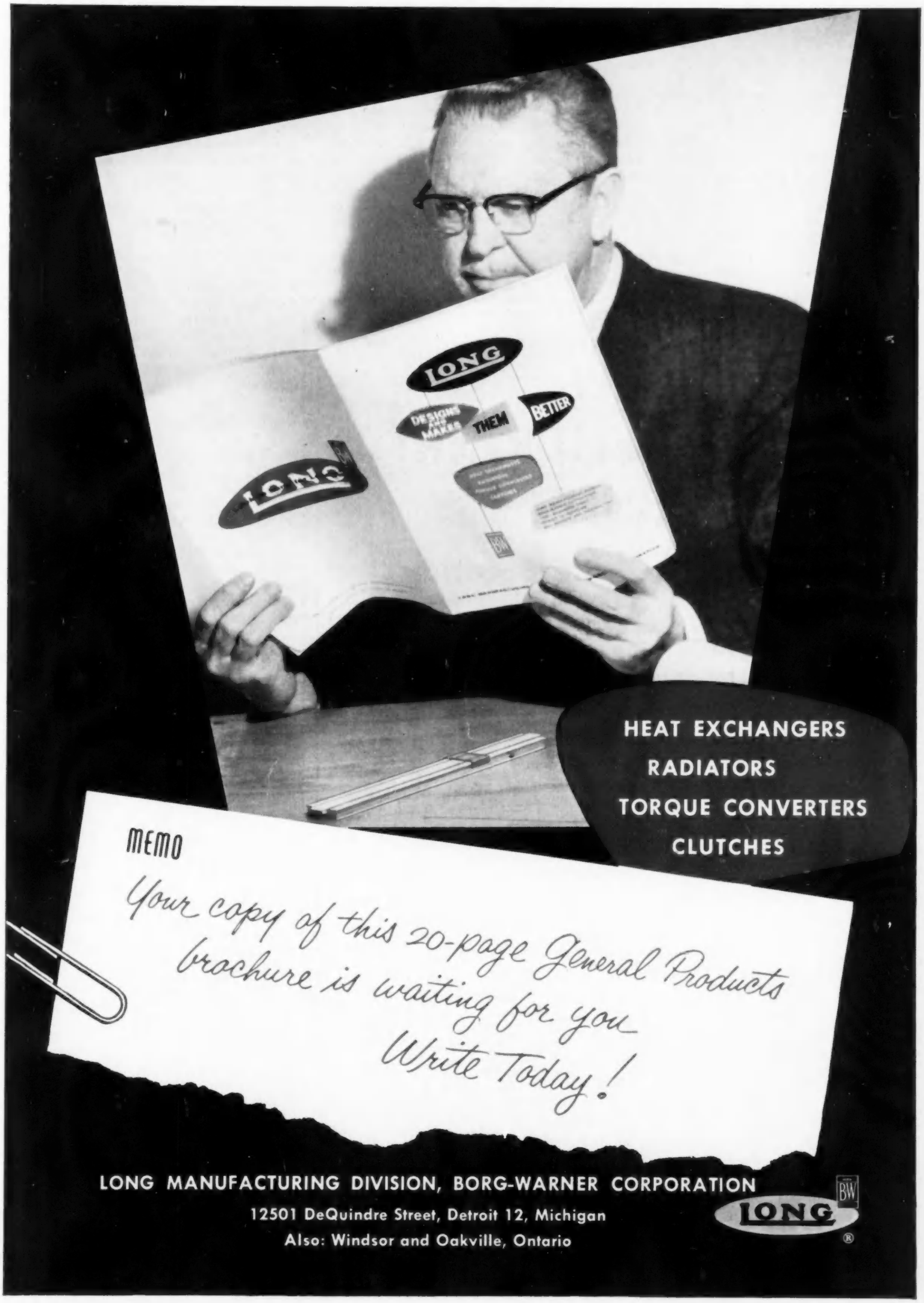
Convair Div., General Dynamics Corp.

IT is easy to design the complicated—the simple takes much longer. Thus the demands for the faster, lighter and heavy load-carrying airplane dull the senses of the designer as he is prodded at an ever faster rate. He can hardly be blamed for forgetting maintenance and service problems.

The early airplane was rather simple in design and did not require too much effort to keep going. But today the airplane is so complex that if you can't get at it to service it, it is useless. This simple truth has been difficult to get over to some of the old-timers. Service must be considered in the preliminary stages of an airplane and the features must be built in. Poor basic service design once incorporated is as difficult to correct as poor aerodynamics.

The integral stairway and carry-it-yourself luggage compartments on the Convair 240 are examples of design to speed the ground handling of passengers. By the same token, design to reduce ground accidents is reflected in the location of servicing points to separate unlike activities around the airplane. While oil and gas trucks are moving into position on one side of the airplane, the passengers are unloading from the other. After unloading, the trucks move to the opposite wing, so that except for refueling on the passenger area side all other operations are performed away from it.

The seat back lock can be overridden by forward pressure on the seat back. This permits the cabin attendant to return the seat to upright position without straining and twisting to reach the control knob. The item may seem in-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significant, but it has saved many maintenance clean-up hours.

In the design of the Model 340, Convair used a metal mockup to speed the engineering and manufacturing program. This permitted the planning and proofing of all electrical wiring and tubing in advance of actual production. With this to-scale structure, routing of tubing, wiring, and location of equipment was easily determined.

Inspection openings large enough to achieve maintenance operations were determined with the mockup and the doors were placed to obtain maximum accessibility and to provide fast complete inspection of all critical points.

In areas where stressed doors are necessary, the door panel is usually hinged at one end and attached with screws on three sides. When open, the hinged panel remains with the airplane, eliminating the chance of panel damage or loss.

Batteries are heavy and awkward to handle, hence an elevator is installed behind a large access panel in the wing (Fig. 1). Within the panel is a small door through which a crank is reached for lowering the elevator to a convenient servicing position.

With maintenance and service personnel in mind, the design engineer developed an orange peel cowling. The panels are attached to the nacelle even during engine change, thus minimizing damage. And being fully cantilevered with the nacelle, the cowling does not vibrate with the engine, thus minimizing wear and repair. (Paper "Air Transport Design for the Human Element of Airline Service and Maintenance Personnel" was presented at SAE Golden Anniversary Aeronautic Meeting, Los Angeles, Oct. 13, 1955. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Based on Discussion

A. E. Smick,
Trans World Airlines, Inc.

The major barrier to efficient and reliable flight operation is the problem of diagnosing and correcting mechanical malfunctioning. With the increased skill developed by years of experience, the airline mechanic can achieve some remarkable results in expeditious removal and replacement of units even when careless design has failed to provide good access. But the technical advances in systems have led to complexities which steadily outdistance those same mechanics. The application of human engineering requires a shift of emphasis from physical to mental considerations.

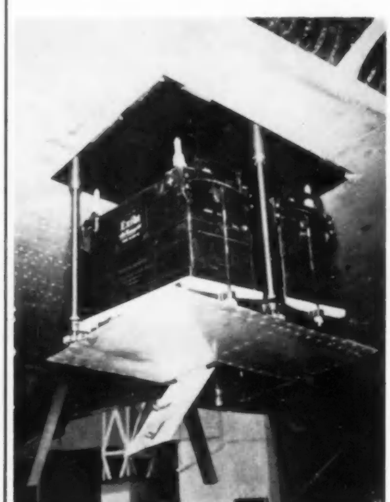


Fig. 1—This aircraft battery elevator simplifies getting at the awkward and heavy batteries for servicing. Turning a crank lowers the elevator to a convenient position.

Aircraft Testing Grows Ever More Complicated

Based on paper by

R. F. WICHSER
Republic Aviation Corp.

SOME severe new problems are being met as higher speeds cause aerodynamic heating of aircraft. Not only do materials lose their strength and stiffness at higher temperatures, but unequal expansion of structures causes distortion and hard-to-analyze stresses.

But these problems are yielding to ingenious test procedures. One indication of the severity of the heating is the requirement of a 1000-hp electric motor to drive test equipment for cabin air-conditioning. Another is that some new hydraulic systems are designed to operate at 500–600 F.

With the increased complexity of aircraft, test departments have been increased in size and breadth of field many times over. Some facilities needed for the more fundamental tests are too expensive for individual aircraft manufacturers. Therefore, much fundamental research is done by the various National Advisory Committee for Aeronautics laboratories or by universities.

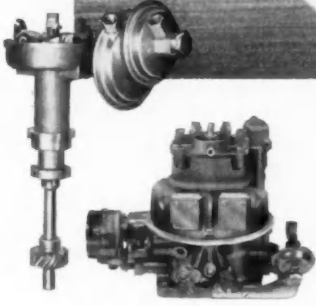
Aircraft test work covers three categories: (1) tests to guide designers (mostly in aerodynamic shapes and structure), (2) tests to evaluate systems, and (3) qualification tests on component parts and assemblies. Tests on a proposed structure such as a wing, may include static load tests of the deflection and strength of a model. Later, when the full-size structure has been built it is tested again for deflection and strength. It also receives cyclic load tests to evaluate its fatigue life and vibration tests to find resonances.

Tests of complete systems often include a full-size system installed in a mock-up. In the case of hydraulic systems such as flight controls, flaps, or landing gear, the system would even include piping of exact size and routing. The loads expected to be encountered are usually applied to the control system by hydraulic cylinders.

Another system tested is the escape equipment for the pilot. In this test the ejection seat was fired in a wind tunnel to check operation of the system and insure that the pilot and seat would miss the vertical tail.

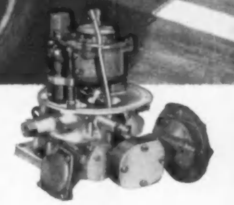
Testing of aircraft antennas insures that the antennas will be able to receive or transmit signals in the proper direction. Difficulty of the problem stems from the large number of antennas carried on modern aircraft. One airplane carried 32 different antennas, all of which had to be positioned to cover a selected area and also had to present minimum wind resistance. Testing is done by reduced scale models at increased frequencies.

(Reported by Field Editor Henry



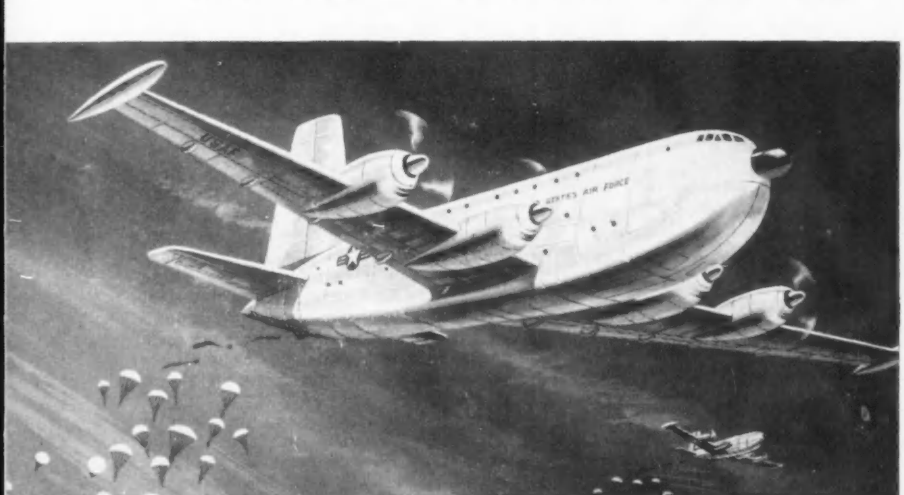
IN AUTOMOBILES—over 10 million of them—you'll find Holley carburetors and distributors. Holley's outstanding record of "firsts" in this field includes the 4-barrel carburetor with vacuum controlled secondary barrels.

IN TRUCKS. More of America's truck engines are Holley carburetor equipped today than are equipped with any other carburetor. Leading truck manufacturers combine Holley's carburetor, distributor and governor for an integrally-designed control system which provides maximum power and maximum economy features.



Engine Control Systems by Holley

"Mechanical Brains" to Control the Power of the Engines of America



Effective control of engine power is not a simple process of fuel metering—rather it is a problem of co-ordinating the many variables in such a way that the pilot's or driver's demand is instantly satisfied in the optimum manner.

For over half a century, Holley has supplied control systems to harness the power of automobile, truck and aviation engines of all types. Holley carburetors and distributors for automobiles and trucks, and turbine controls for jet aircraft provide maximum efficiency and minimum operating costs for today's engines.

Wherever control systems are needed — for auxiliary or main power plants — Holley's half a century of design, engineering and manufacturing experience can best meet your requirements.

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Wakeland. Paper "The Role of Testing in Modern Military Aircraft Design" was presented at SAE Metropolitan Section, New York, Sept. 15, 1955. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Undercarriage Sealer A "Must" for Protection

Based on paper by

G. A. PETHICK

Sherwin-Williams Co. of Canada, Ltd.

OPERATORS concerned with vehicle upkeep should be warned that price per gallon is no index of the value of underframe blacks offered for chassis refinishing. The cheap products may act no better than colored whitewash and offer no effective resistance to the action of moisture, salt, gasoline, and other deteriorating agents.

Liberal use of the newer undercarriage sealers is strongly recommended to fleet owners who operate in metropolitan areas where calcium chloride is spread on the streets during winter. The satisfactory adhesion of these special asbestos fiber undersealer coatings and their maximum resistance to deteriorating agents depend wholly upon the cleanliness and dryness of the metal surfaces over which they are applied and which have been prepared by thorough steam-cleaning or sandblasting operations. These undercarriage sealers are also excellent sound deadeners.

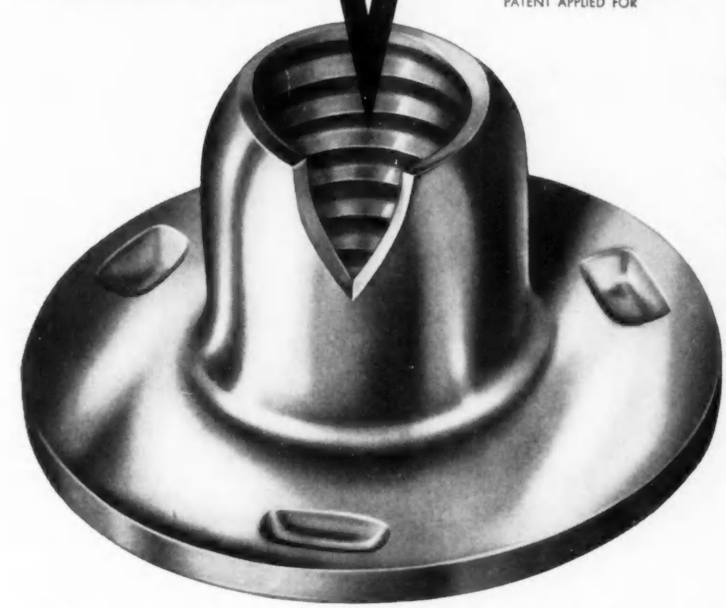
Vehicle operators who use special color combinations for advertising purposes should keep in mind that there are certain shades and colors that lose their original gloss and color relatively fast. Thus, the sales appeal is quickly lost while upkeep costs are increased.

When using maroons or other more or less transparent colors be sure to use a good ground coat under the new colors. These can often be made up in your own shop by mixing surplus, or overstocks, of certain colors. Where you are using a prime surfacer, select a color that will serve as a good ground coat. In addition to light and dark grays, and red oxide, better ones are now available in white, pink, or yellow shades.

Blued-whites that have all the color and gloss retention of the natural whites can now be purchased. These are of special value to fleet operators handling dairy and other food products. (Paper "We Live in a World of Color" was presented at SAE Montreal Section Meeting, Dec. 12, 1955. It is available in full in multilith form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

NEW V-LOCK TEENUTS®

PATENT APPLIED FOR

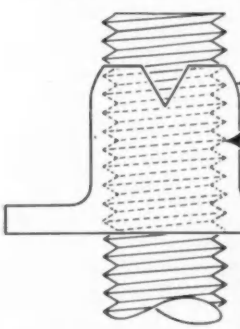


- **self-locking**
- **vibration-proof**
- **one-piece construction**
- **proven effectiveness**
- **highly adaptable**
- **re-usable**

The upper portion of this precision-made Teenut incorporates a V-type notch with the circumference of the barrel compressed inwardly toward the axis to form a permanent set. This makes it a re-usable, prevailing-torque-type, self-locking nut.

It is a one-piece, self-contained unit in which the self-locking device is an integral part of the design. No non-metallic materials or stamped parts are used so that the V-lock Teenut is not affected by heat or oils and has high tensile strength.

As the V-lock Teenut does not rely on base load to obtain its friction grip, it may also be used as a stop nut. (Indentations in base flange are welding bosses).



Bolt spins freely into nut until it reaches gripping area. Then, spring action creates strong, metal-to-metal wedging force, locking threads of bolt and nut together to make assembly virtually vibration-proof. Bolt may be removed and replaced many times without loss of effectiveness in nut.

The V-lock Teenut is but one of thousands of special purpose fasteners designed and manufactured by United-Carr to help speed assembly, cut costs and improve product performance. For further information on the V-lock Teenut or for help with any other fastening problem, consult your nearest United-Carr field representative or write us for his name and address.

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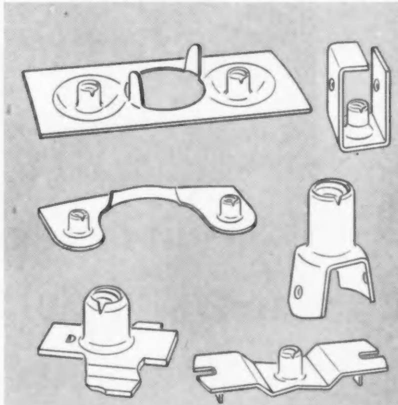
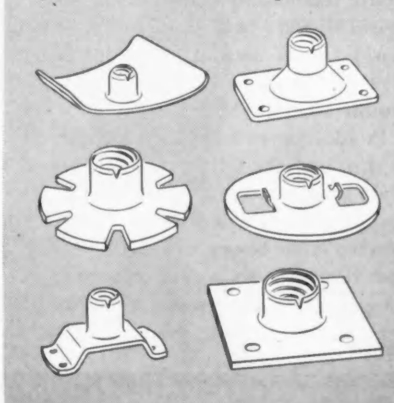
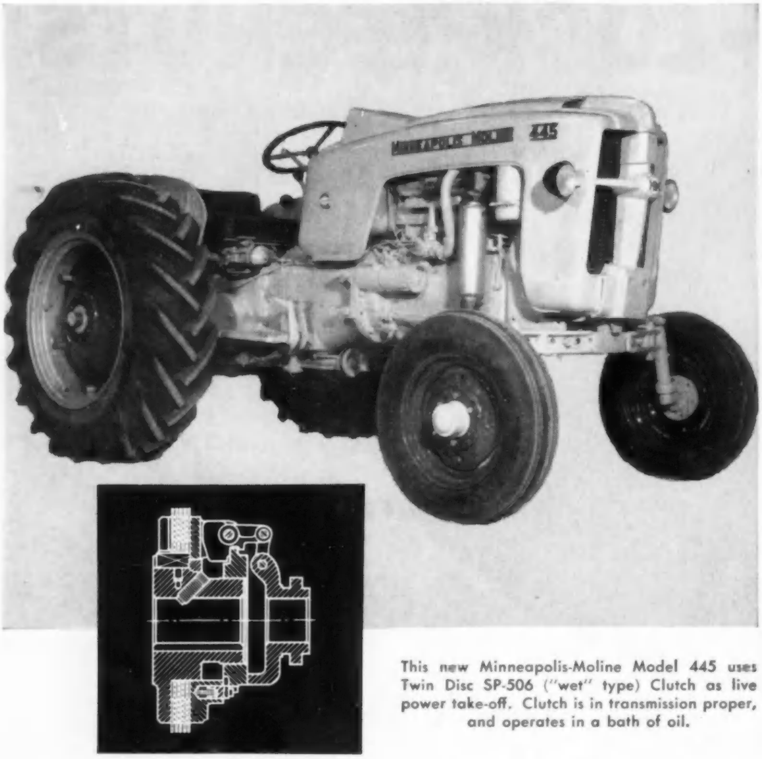


UNLIMITED VARIETY

V-lock Teenuts can be engineered in various shapes and sizes to suit customer's specifications. Can be manufactured *in volume*... in brass, bronze, stainless steel, aluminum, etc.... with unified screw threads, class 2B, in both coarse and fine thread series. Finishes: zinc, cadmium, chrome, parkerized, etc. to customer's specifications.





SP News About Special Publications

CARS WITHOUT CARBURETORS are on the way. How long before fuel injection becomes standard equipment on passenger cars? Read what the experts think in SP-140, a symposium on Fuel Injection for Gasoline Automobiles, now available. Price: $1.50 to members; $3.00 to nonmembers. This up-to-date special publication is a compilation of the latest views on this vital subject by the industry's leading authorities.

PUTTING AIRCRAFT INTO THE AIR requires thorough grounding in the fundamentals of aircraft production. These fundamentals and more advanced techniques are published in a special publication (SP-313) based on the discussions at the Aircraft Production Forum at Los Angeles, Oct. 11–12, 1955. This 121-page report of 15 production panels contains the high points of the forum discussions, with illustrations and graphs. Price: $2.00 to members; $4.00 to nonmembers.

WHAT HAPPENS TO A PLANE AT HIGH SPEEDS? How do the forces acting on aircraft at high altitudes and speeds affect the pilot? How can this information be obtained? These and other questions on "Environmental Testing of Aircraft and Missiles" are discussed in a special publication (SP-141) which is now available. It is based on a seminar of eight technical papers plus an introductory talk which was presented by the Southern California Section, Dec. 5, 6, and 7, 1955. Price: $3.00 to members; $6.00 to nonmembers.

MAKE THE VEHICLE FIT THE DRIVER—For safety as well as for comfort, vehicles should be designed to fit the human body, say engineers from Harvard's School of Public Health, in a recent report. This special publication (SP-142) entitled "Application of Human Body Size Data to Vehicular Design" gives pertinent body dimensions of thousands of drivers and recommends cab dimensions based on these sizes. Price: $1.00 to members; $2.00 to nonmembers.

New Members Qualified

These applicants qualified for admission to the Society between January 10, 1956 and February 10, 1956. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

Atlanta Section

Robert F. Stoessel (M).

Buffalo Section

Arthur C. Bennett (J), Gale H. Buzzard, II (J).

Canadian Section

John Norsworthy Cram (M), J. L. Forster (J), Stanley C. Goodwin (A), Miles H. Hudspeth (A), Theodore J. Kish (J), Franciszek Kresowski (A), William John Muller (J), James C. Richardson (J), Herbert Ray Schlichter (A), Harvey R. Smith (M).

Central Illinois Section

Lester D. Bergsten (J), Robert C. Brown (M), Don M. Dinquel (J), Carl R. Maxwell (M), Kenneth L. Schafer (J), William C. Schreiner (J), James W. Voth (J), Dale J. Wright (M).

Chicago Section

Gordon C. Badley (J), Joseph F. Bakel (J), Adam Keith Blackwood (M), Dr. John A. Carlson (J), Rudolph H. Cook (J), George W. Dennis (A), G. Robert Harting (M), Lawrence H. Hodges (M), Edward E. Hupp (M), Owen C. Jackson (A), Thomas N. Kasabali (J), William A. Leeper (M), Bert W. McCleneghan (M), Elliot S. Nachtman (M), Frederic J. Norman (M), James J. O'Sullivan (A), Paul E. Pfeifer, Jr. (M), Willard V. Putz (M), D. L. Ries (J), John Rusnak (A), Mervin E. Shanafelt (M), Robert Simmons (J).

Cincinnati Section

Bruce L. McMillan (M).

Cleveland Section

Murray D. Braid (M), John J. Brogan (A), Albert Wesley Cook (M), J. N. Crawford (M), W. Culver Hale (A), Roger R. Klatt (J), William A. Michaels (J), J. J. Pirnat (A), Dean C. Reemsnyder (M), Charles W. Sanford (M), Dr. Ralph A. Schaefer (M), Louis J. Schafer, Jr. (M), Charles B. Small (M), Kenneth C. Wessel (A).

Colorado Group

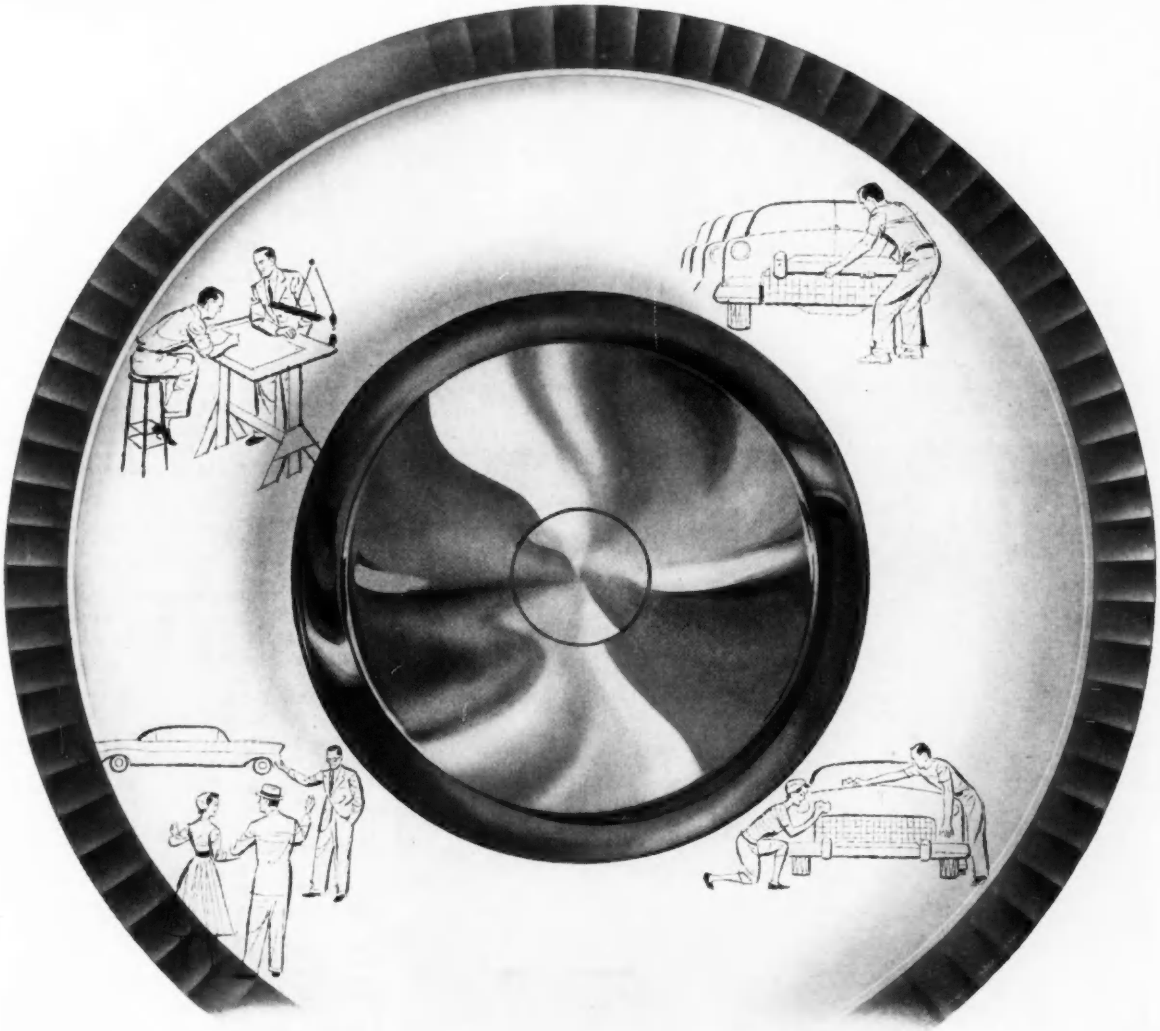
Robert R. Atchison (A), 2nd Lt. James Broemer (J).

Dayton Section

Ralph A. Bowerman (M), Thomas J. Lord (M), 1st Lt. Richard E. Rinearson (J), John H. Smith (M).

Detroit Section

Frederick C. Aebersold (J), Warren M. Beevers (J), William A. Biddle (M), James Eric Black (M), Stanley Bonzack (M), Gordon D. Brooks (J), James D. Buescher (M), J. H. Campbell (J), Alfred L. Carter (J), James H. Cowen (J), Richard J. Crane (M), Stephen A. Csorgo (M), James W. Dean (J), Theodore DeBoer (M), Robert Doyle Firth (J), Donald E. Gauthier (J), Albert J. Graumlich (M), James J. Gumbleton (J), Herbert F. Hames (J), Louis W. Huellmantel (J), Franklin N. Jenkins, Jr. (J), C. S. Johnson (A), Conrad Kaspers (A), Thaddeus Kaszubowski (J), Norman R. Keck (M), John Koinis (J), Louis S. Leonard (M), Alexander J. Lobbestael (M), Wallace A. Lobdell (J), Gary S. Long (J), Charles E. Luxmoore (J), Donald J. MacIntosh (J), Joseph N. Mazur (J), Wesley L. McCollum (J), James P. Meloche (J), Ralph H. Merkle (M), James J. Murtagh (A), William U. Nelson (M), Gilbert H. Newbury (M), Ned F. Nickles (M), John Nixon (J), George N. Payne (A),



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New Members Qualified

continued

Leonard J. Piconke (J), Kenneth I. Postel (M), Robert J. Regenhardt (M), William Reid (M), James M. Ricketts (M), Franklin H. Schafer (A), Emerald G. Schenk (M), George S. Scott (A), Zachary W. Smith (M), Robert J. Spillman (M), Ray W. Springer, Jr. (A), Charles G. Sterling (M), Robert I. Thomas (A), Jay W. Thornburgh (M), Herbert Oskar Tieva (M), Edmund Towers (M), George W. Walker (M), Doyle Warner, Jr. (M), William Thurman Wells (M), Richard A. Wilson (J), Michael H. Wolfbauer, Jr. (M), Wallace E. Wright (J), Tao-Yuan Wu (J).

Hawaii Section

Kenneth Lewis Hensley (A), Thomas R. H. Lillie (A), George K. Sereno (M).

Indiana Section

Thomas W. Binford (A), Charles E. Cook (J), John Larry Hall (J), Thomas F. Havens (M), Robert Highland (A), Edward J. Mateja (J), Angelo S. Miceli (M), Joseph A. Naughton (J).

Metropolitan Section

William J. Bowen (J), James A. Corson (J), Harry Dornbrand (M), Walter A. Herbst (M), John W. Hyde (M), Max A. Labhart (M), Richard R. Ledesma (J), Torsten H. Lindbom (M), George E. Merkle (M), Robert A. Paulsen (J), Lawrence E. Putnam (M), William T. Ray (J), Lt. Col. Robert W. Samz (M), Irwin Saretsky (J), Henry Voorman, Jr. (J).

Mid-Continent Section

W. Nelson Axe (M).

Mid-Michigan Section

Harry L. Eiferle (A), Robert L. Kersten (J), Harold W. Noponen (M), Clifford James Wing (J).

Milwaukee Section

Earl F. Dau (A), John A. Gresch (J), Peter D. Humleker, Jr. (A), George Eric Otto (A), Sigurd K. Rudolf (M), Herschel A. Setser (M), John W. Speaker (M), LaVern R. Tietz (M).

Montreal Section

Ian C. Colquhoun (J), A. Ronald McKay (J), Glen M. Pearson (J), John E. Rehder (M), W. G. Smith (A).

New England Section

Anthony Deltufo (A), Harold B. Gordon (A), Richard S. Weiss (M).

Northern California Section

Douglas John Aberle (M), Leslie L. Aldrich (J), Fredrick S. Bonney (M), John T. Sullivan (M).

Northwest Section

Richard K. Fergin (J), William S. Stirling (A).

Oregon Section

R. E. Peterson (A).

Philadelphia Section

Lawrence D. Barrett, Jr. (M), Donald G. Civitella (J), August John Dielens (M), Victor D. Hajj (M), Paul E. Oberdorfer, Jr. (M), Ethan A. Smith, Jr. (M).

Pittsburgh Section

Samuel H. Miller (A).

St. Louis Section

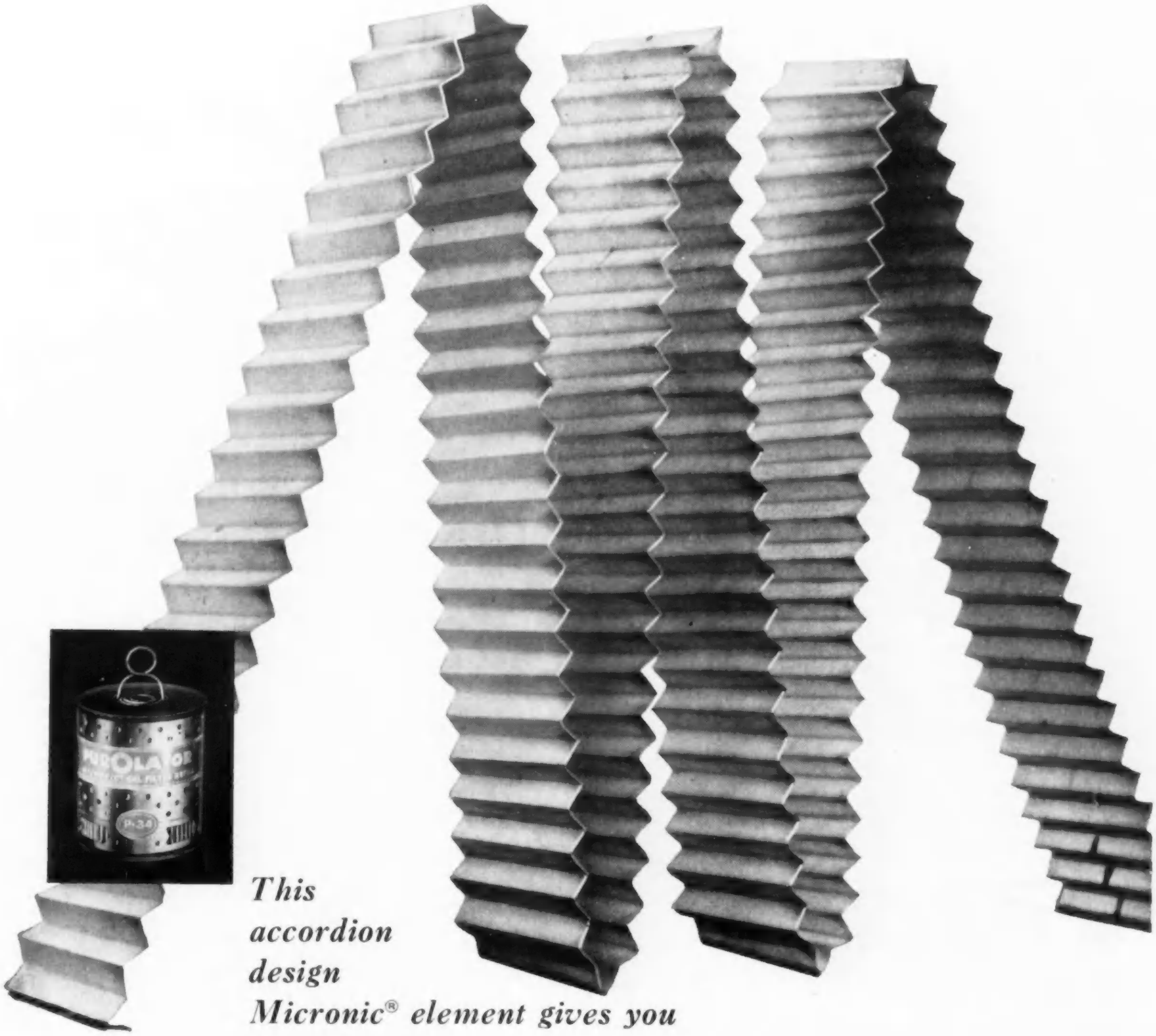
C. Richard Groninger (A).

San Diego Section

Harry Croome (A), Ted A. Matera (J).

Southern California Section

Robert W. Beavis (J), Frank W. Belina (J), Clyde S. Burkhardt (J),



This accordion design Micronic® element gives you

10 times more filtration area for full engine protection

Pull out Purolator's accordion design and you'll see how Purolator packs 10 times more filtration area into its element than most filters. You'll find it provides maximum filtering area in minimum space, assuring *full* engine protection as no other filter does.

Controlled porosity of Purolator's Micronic® element filters out particles as small as .000039 of an inch, yet never removes costly additives in heavy-duty or detergent oils and never channels. The Micronic® element, made of plastic-impregnated cellulose, isn't affected by engine temperature, crankcase dilution, or water.

Engine manufacturers have proved time and time again that these wear-reducing features make an engine perform better and last longer. Find out how they can do the same job for you. Write for our new 32-page "Filtration Manual for Product Designers"—and please enclose 25¢ to cover postage and handling. Address Dept. A4-317.

PUROLATOR

"FIRST IN THE FIELD OF FILTERING"

PUROLATOR PRODUCTS INC., Rahway, N. J., and Toronto, Ontario, Canada

New Members Qualified

continued

Charles R. Dauwalter (J), Arthur V. Fitzwater (J), Harold Greer (J), Howard D. Houghton (M), Waldon T. Johnson (M), Dr. James L. Keller (M), Paul W. Knaebel (M), Henry N. Mabery (A), Leonard J. Malin (J), Paul S. McKibben (M), John Eric Michel (J), Robert G. Reichmann (J), John E. Wilson (M).

Southern New England Section

Carl Franz Christian (J), Adolph V. S. Mongillo (M), Peter T. Vercellone (J).

Spokane-Intermountain Section

R. E. Edens (M).

Syracuse Section

Thomas A. Kesel (J), Warren M. Meaker (A).

Texas Section

Carol C. Carbaugh (J), Edward E. Ellis (A), William B. Grigsby (A), Henry I. McGee, Jr. (M), Alexander A. Sinclair (A).

Texas Gulf Coast Section

William D. Gilder (M), Luther L. Harris (J), James E. Shamblin (J), Douglas J. Skinner (J), Russell C. Sullivan (M).

Twin City Section

Peter A. Thor, Jr. (J), Glen J. Tobias (J).

Washington Section

Franklin H. Baldwin (M), R. W. Beal (M), Phil S. Hollar (A), Jordan E. Johnson (A), Hubert E. Maben, Jr. (A).

Western Michigan Section

Calvin N. DeBruin (J), Ralph P. Lillmars (A).

Wichita Section

James R. Dennison (A), Edwin D. Manspeaker (A).

Outside Section Territory

Richard E. Dannan (J), James K. Draper (M), Major Gen. Francis H. Griswold (M), Scott R. Harrison (A), Robert L. Hughes (A), Robert D. Johnson (M), Kenneth V. Ludlum (M), Harlie LeRoy Lunke (A), Buster B. Poston (A), George J. Stevenson (A).

Foreign

Raj Nath Bhel (J), India; Kenneth James Mathieson (A), England; Cyril G. F. Pritchett (M), England; K. Sampath (J), India.

Applications Received

The applications for membership received between January 10, 1956 and February 10, 1956 are listed below.

Alberta Group

Leslie A. Dulmadge, Morris W. Tees.

Atlanta Section

Charles R. F. Beall, Jr., Thomas P. Garden, Charles C. Smith.

Baltimore Section

Lef W. Kenyon.

Buffalo Section

George E. Millet, R. Douglas Rumsey.

Canadian Section

Douglas Andrew, Samuel G. Curtis, James S. Hart, Clarence D. Jacobs, Roger W. Wade, John D. Wood, Russell C. Workman.

XIV

This is the fourteenth of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

Silicon - What It Is and What It Does in Alloy Steels

Silicon is a very abundant nonmetallic element, one of the chief elementary constituents of the earth's crust. In the form of ferrosilicon, it is used by steelmakers as a deoxidizer and hardener in both alloy and carbon steels.

When the maximum silicon content is specified within the limits of 0.60 to 2.20 pct, the resulting steel is classed as a silicon alloy steel. However, all other standard alloy grades are specified to a range of 0.20 to 0.35 silicon for purposes of deoxidation. Silicon has several interesting effects, among them three that should be noted carefully: (1) it raises the critical temperature for heat-treatment; (2) as the amount is increased, it increases the susceptibility of steel to decarburization and graphitization; (3) combined with other alloying elements such as nickel, chromium, and tungsten, it promotes resistance to high temperature oxidation.

Silicon-Manganese Steels

Of the alloy steels relying heavily on silicon, one of the most important groups is the silicon-manganese series. As mentioned above, silicon is recognized as a deoxidizing agent, and a powerful one. Manganese behaves in the same manner but to a lesser degree.

Manganese exerts beneficial effects on the mechanical properties of heat-treated steel. Silicon as an alloy increases the strength. A properly balanced combination of the two elements produces a steel with unusually high strength, and with good ductility and shock-resistance.

Silicon-manganese steel has been widely used for the making of coil and leaf-type springs. It has also been used successfully for chisels, drift pins, punches, shear blades, mine bits, and other products that must be shock-resistant. It responds readily to oil-quenching, and when tempered at the correct temperature, it possesses not only shock-resistance but toughness and strength.

We invite you to consult with Bethlehem metallurgists whenever you wish to know more about silicon and its uses in steel. If you care to have them do so, these technicians will gladly suggest the proper analysis for your particular needs. Whatever it is, Bethlehem can furnish it, for Bethlehem makes all AISI standard alloy steels, as well as special-analysis steels and the full range of carbon grades.

If you would like to have a reprint of this advertisement, or of the entire series from I through XIV, please write to us, addressing your request to Publications Dept., Bethlehem Steel Company, Bethlehem, Pa.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

Applications Received

continued

Central Illinois Section

Frederic P. Buttke, Lyle E. Eaton, Niles J. Fisher, Edwin M. Kirchgessner, Weldon A. Swanson, H. Walter Zerlaut.

Chicago Section

Virgil D. Angerman, Edward J. Beth, Herbert J. Germann, Carl D. Halverstadt, Max L. Howard, Leon C. Hummel, Homi Kapadia, W. W. Matzke, Walter T. Miiller, Joseph J. Rossiter, Charles R. Slaght, Martin S. Vasek, Ira H. Wahlbeck, Joseph J. Wylie.

Cincinnati Section

Everett W. Denison.

Cleveland Section

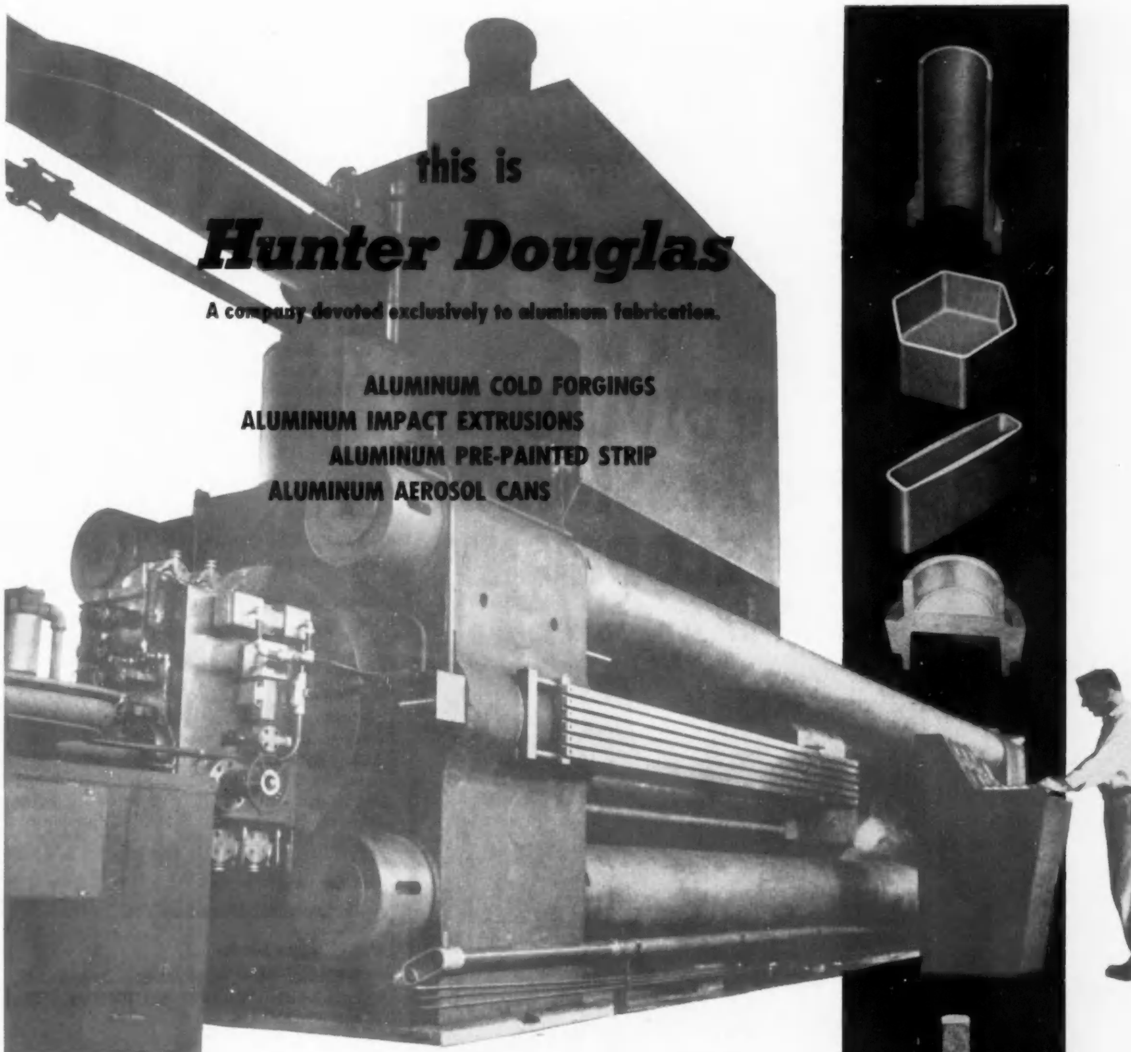
Lawrence E. Biggs, Richard E. Clark, Ted R. Diegel, Robert T. Drake, George H. Hilderbrand, Jr., Paul R. Houser, Clyde C. Logue, Jr., John B. O'Donoghue, Frederick J. Port, Walter H. Robinson, Fred Anthony Sheplavy, A. J. Stromquist, Jerry J. Taborek, Clarke F. Thornton, John R. Wood.

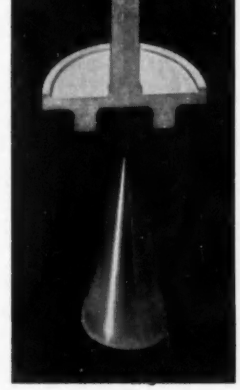
Dayton Section

Alfred R. Brenholts, Paul E. Erbaugh.

Detroit Section

Wayne S. Anderson, George T. Ansen, James P. Beakley, Joseph E. Beaudin, Gerald Bogacki, Frank J. Bognar, Raymond M. Bosworth, Jr., James O. Brafford, Donald W. Bridges, LaVerne D. Brown, William E. Brunsdon, Selden D. Burchenal, Jr., Wayne E. Canfield, Albert W. Carion, Robert M. Cromwell, John E. Curtis, Clair G. Dibert, George F. Dixon, Phillip Dmetroshko, William J. Doherty, Richard L. Drake, Gene R. Dunifon, Edwin F. Dyer, Edward J. Dzenko, Edwin Lee Etnyre, Francis K. Fermoyle, Roy W. Fogle, Robert H. Fredericks, Raymond A. Gallant, Thomas V. Godsil, Douglas C. Harding, Bill J. Hemenway, John C. Hergert, Harry D. Hirsch, Wallace S. Holbrook, Drew S. Holt, James W. Houston, James R. Ignatowski, Ernest A. Jackson, Henry R. Jaeckel, Theodore K. Jamieson, Paul M. Jensen, William K. Jensen, Max S. Johnson, Robert L. Jones, Maurice D. Karlstad, Jr., John S. Kerr, Byron J. Kerry, John L. King, Jr., William A. Kohn, Earl F. Kotts, Ernest C. Kron, Harold A. Kuypers, Hugh W. Larsen, Casimir J. Lignowski, William L. Lindsay, Roger D. Locke, John G. Locklin, James G. Maier, Zar Malkasian, Harold E. Marcum, Ronald C. Mason, Jack E. Maxwell, John A. McCabe, Marshall M. Meads, Harold D. Michel, Robert R. Miller, Joseph D. Mirto, Robert A. Moriset, Anthony J. Muller, Henry B. Mullholland, Albin J. Niemiec, H. P. Oldham, Joel M. Opsomer, Claude A. Patalidis, Matthew C.





The name and reputation of Hunter Douglas stems from many activities related to aluminum fabrication. Cold forging of aluminum and its alloys is an important contribution. Advanced cold forging techniques, coupled with constantly growing facilities, now place Hunter Douglas among the world's leading suppliers of aluminum cold forgings and impact extrusions.

Unusual integration of plant facilities from raw material to finished product supply strong economic advantages for using this comparatively new aluminum cold forging process. Many "firsts" in solving complex tooling problems at Hunter Douglas have tremendously increased the scope of cold forging... in variety of part geometry and in component size.

Hunter Douglas engineering and fabrication resources can work to your advantage when parts are required in mass quantities. Our sales engineering department will welcome the opportunity to assist in developing your aluminum cold forging applications.

Detroit Sales Engineering Office:
16722 E. Warren Ave., TUxedo 2-0232

Hunter Douglas Aluminum Corporation

HUNTER DOUGLAS ALUMINUM CORPORATION • DEPT. SA-3, RIVERSIDE, CALIFORNIA • TELEPHONE OVerland 3-3030

Applications Received

continued

Patterson, Jr., Ray B. Pettibone, Keith F. Pickering, Thomas H. Poyer, Wesley E. Ravell, James A. Read, Edward B. Rials, Louis R. Ross, William J. Ruby, Roger J. Schroeder, Robert C. Sheridan, Jack T. Stevenson, Jerry M. Strang, H. A. Tooman, Richard C. Unger, Albert E. Vandermarliere, Richard D. Vartanian, Paul T. Vickers, Max M. Wachowiak, Edward J. Walsh, Gordon C. Wange, Wayne D. Warner, Arthur E. Woizeschke, Homer F. Wood, Kenneth O. Young, John R. Zimmerman.

Indiana Section

Francis X. Andrews, Boyd L. Bonner, Lawrence L. Harrison.

Kansas City Section

Maurice G. Nix.

Metropolitan Section

George B. Achtmeyer, Arthur V. Agresta, Argyle V. Ballard, John F. Ceccarelli, John F. Creamer, Jr., Anthony DeSalvo, John P. Frain, Charles E. Gruen, Edmund D. Holland, John B. Lowell, Jr., Hector Munro, Robert F. Schwarzwalder, Donald W. Weed.

Mid-Continent Section

Jackson W. McKinzie.

Mid-Michigan Section

William C. Eberline, Jacob N. Groeneveld, Walter A. Horner, Jr., Ward D. Miller.

Milwaukee Section

Ralph L. Bauer, R. G. Everist, John W. Gottwald, Carl A. Handtke, Anthony J. Secola, R. S. Stevenson.

Mohawk-Hudson Section

Charles H. Anderson.

Montreal Section

C. R. Curtis, Ronald E. Foster, George L. Kingston, Rene Lavoie, Charles D. Parmelee, Alfred B. Rode, William E. Rose, William G. S. Thomas.

New England Section

Charles J. Bry, Jr., Woodrow W. Foss, Stanley H. Franklin, James F. Jefferson, Richard L. McManus.

Northern California Section

Raymond P. Bartlett, C. Allan Fechser, Edward J. Putryae, C. Adair Roberts, Vincent Villasenor.

Northwest Section

Cecil R. Bickle, Guido Hanning, Marvin R. Kuehnoel.

Applications Received

continued

Oregon Section

Robert L. Elliott, Jacob Esch.

Philadelphia Section

John J. Greytak, Terry T. Hall, Hans G. Krauss, Gerald D. Nepon, Clifford A. Smith, Samuel C. Smith, Jr., Philip M. Walters.

Pittsburgh Section

William L. Bruckart, Edward M Flaherty, Adolf F. Stark.

St. Louis Section

William Lee Gabbert.

Salt Lake Group

M. A. Gard.

San Diego Section

Karl H. Montijo, Darwin S. Whetstine.

Southern California Section

Thurlow S. Culley, Jr., Ted Grondona, Raymond H. Heller, Rowland H. Nowell, George W. Papen, Jack Prikett, Derwyn M. Severy, Peter Valenti.

Southern New England Section

William F. Brown, Hans A. Maurer, LeRoy C. Zastovnik.

Texas Section

James W. Callahan, Foster M. Poole, Frank B. Whalen.

Texas Gulf Coast Section

Frank J. Wehking.

Washington Section

Brig. Gen. Pierre A. Brison, Frank R. Caldwell.

Western Michigan Section

Frank L. Pecott, Harley R. Smith.

Wichita Section

Wilson Simmons.

Williamsport Group

Raymond A. Breining.

Outside of Section Territory

Max E. Counts, John C. Curtiss, John L. Heinlein, Duane Elwood Hinds, Charles R. Johnson, Donald G. Parker, Robert W. Petersen, Paul Zivkovich.

Foreign

Leonard C. Dempster, Bermuda; James B. Evans, Hong Kong; Biyagamage C. Fernando, Ceylon; Zvi Gregory Levinson, Israel; Horacio Shakespear, Argentina; A. Subbiah, India.

SPICER ENDS

Spicer *Thornton POWR-LOK* Keeps Power

DANA CORPORATION · TOLEDO 1, OHIO

"WILD WHEELS!"

Geared to BOTH Driving Wheels!

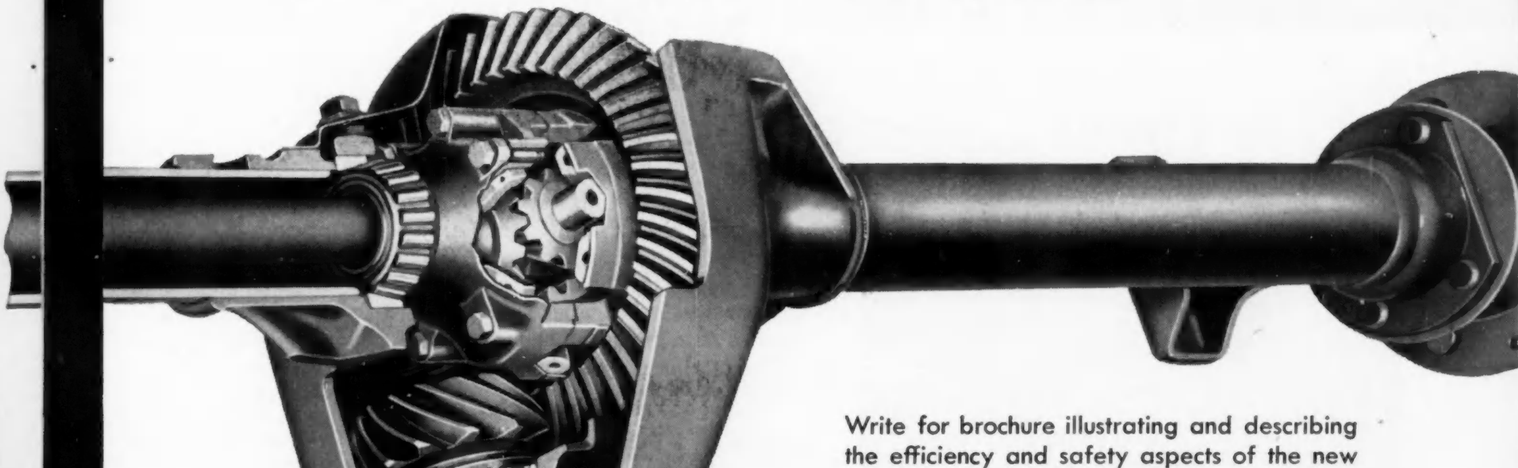
THE Thornton POWR-LOK principle is another in the ever-growing list of safety- and power-transmission innovations developed by Dana engineers and Dana resources. It is a new concept of controlled driving-wheel power . . . the most revolutionary rear axle design in volume production since the invention of the differential itself!

The Thornton POWR-LOK Differential in Spicer Axles now makes possible the automatic delivery of controlled torque to BOTH driving wheels under all tractive conditions, and ends "wild wheels" often occurring in ordinary axles.

No more "wild wheels" that spin uselessly in mud, ice, sand or snow. The Thornton POWR-LOK Differential enables the wheel with the *better* traction to apply the *major* driving force to the road, thereby enabling the vehicle to move.

No more "wild wheels" that spin at high speed when bounced into the air by bumps or holes and then come down with sudden stoppage, causing dangerous car swerve or destructive tire scuffing.

The Spicer Thornton POWR-LOK keeps delivering safe, controlled torque to BOTH wheels at all times, adjusting itself instantly to varying road conditions, and assuring steady propelling action to the vehicle.



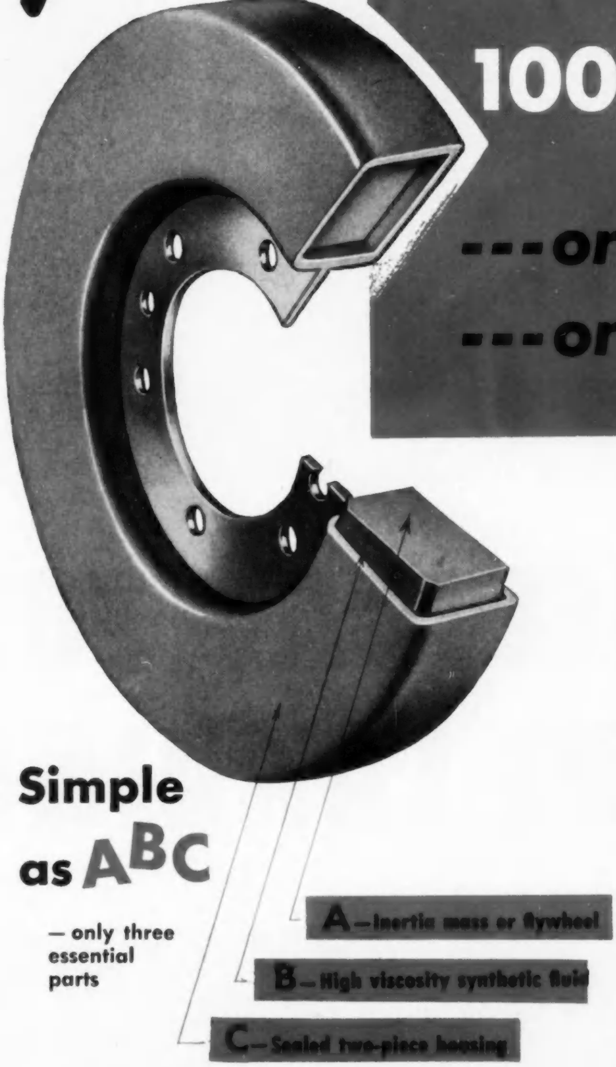
Write for brochure illustrating and describing the efficiency and safety aspects of the new Thornton POWR-LOK Differential as now offered exclusively in Spicer Axles. Available for passenger cars, and light and medium-duty commercial vehicles.

Spicer

SPICER PRODUCTS: TRANSMISSIONS • UNIVERSAL JOINTS • PROPELLER SHAFTS • AXLES • TORQUE CONVERTERS • GEAR BOXES • POWER TAKE-OFFS
POWER TAKE-OFF JOINTS • RAIL CAR DRIVES • RAILWAY GENERATOR DRIVES • STAMPINGS • SPICER and AUBURN CLUTCHES • PARISH FRAMES • SPICER FRAMES

Now Warranted FOR 100,000 MILES

---or 1 year
---or 4,000 hours



Simple as ABC

— only three essential parts

— minimizes both major and minor critical orders of vibration

Patented in U.S.A. and foreign countries

The performance and dependability of the fully patented Houdaille Viscous Torsional Vibration Damper is well known to more than 25 makers of gasoline and diesel engines.

Since its introduction 10 years ago, it has been smoothing the performance and protecting the life of *millions* of engines.

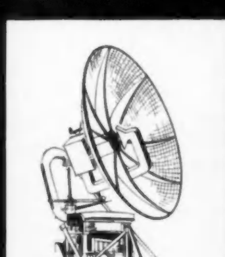
Houdaille now backs this record with a 1-year, 100,000-mile, 4,000-hour Warranty (whichever occurs first) against defects in workmanship and material . . . the *first* of its kind in the industry.

Houdaille engineers will be glad to design a Viscous Torsional Vibration Damper to meet the individual characteristics of your engine, large or small.

HOUDAILLE INDUSTRIES, Inc.*

BUFFALO HYDRAULICS DIVISION | 537 East Delavan Avenue, Buffalo 11, N. Y.

**formerly Houdaille-Hershey Corporation*



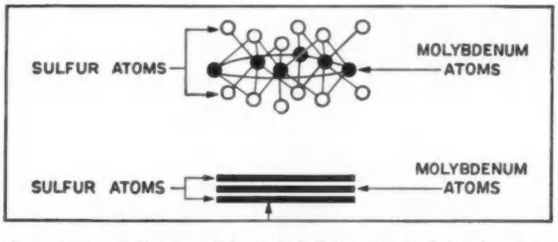
Effective lubrication of torsion suspension bushings of heavy duty trailers has been a maintenance problem with many truckers. The bushing at the left was removed still in good condition after 160,000 miles of service. This bushing was lubricated with a chassis grease containing Moly-Sulfide additive. The bushing at the right, lubricated with ordinary chassis grease, needed replacement after 35,000 miles of service.

How Moly-Sulfide additives EXTEND EFFECTIVE LUBRICATION

Why Moly-Sulfide additives are used in lubricants by trucking fleet operators, railroads, aircraft and automotive manufacturers, oil well drillers and steel mills.

Moly-Sulfide has six characteristics which make it an ideal lubricant additive wherever mechanical action wipes or shears off the hydrodynamic film.

1. Because of its affinity for metals, Moly-Sulfide readily forms a film on metal surfaces.
2. Moly-Sulfide has a low coefficient of friction.
3. It has a high factor of durability.
4. Moly-Sulfide has a thermal stability of –100°F. to +750°F.
5. It has a high chemical resistance to acids, alkalis and water.
6. It withstands high pressures, having a low shear strength and a high film strength.

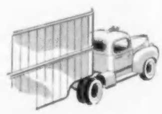


Above, structural diagram of the Moly-Sulfide molecule. Below is a functional illustration of the laminar structure. Each lamina is composed of a layer of molybdenum atoms with a layer of sulfur atoms on each side.

What is Moly-Sulfide and how does it function in lubrication?

Mined in Colorado as molybdenite, purified Moly-Sulfide is a lead-grey material. It has a laminar molecular structure, with the Moly atoms sandwiched between layers of sulfur. (See illustration.) The sulfur atoms have an affinity for metal and

bond readily to metal surfaces, giving the film a *low shear strength.* This affinity is caused by a strong intermolecular bond between sulfur and metal. The lubrication results from the easy slippage of sulfur-to-sulfur atoms. As an additive to lubricants, the *Moly-Sulfide will readily form a film and when a grease or oil film is wiped away or sheared off, the Moly-Sulfide film sustains lubrication until a petroleum film reforms.*



Truck and passenger car builders and operators are making wide use of Moly-Sulfide greases for difficult lubrication jobs.

Lubricants containing Moly-Sulfide additive have over 30 established uses in the automotive, aircraft, railroad, oil drilling and steel industries.

Since Abraham Lincoln's time, railroads have been faced with a serious, recurring, *expensive* problem: hotboxes. Right now more than 14 million journal bearings are carrying heavy loads at high speeds on American railroads. These railroads have to deal with an average of 183,000 hotboxes a year at a cost of some $90,000,000.

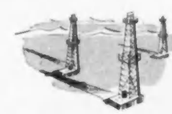
Initial field tests by at least three leading railroads have shown hotboxes can be reduced materially by the use of grease containing Moly-Sulfide. A way has been devised to apply greases containing Moly-Sulfide on the journals of railroad equipment. This application is supplemental to the oil waste system and as a result the Moly-Sulfide films that are formed sustain lubrication until the oil film is reestablished.

American automobile and truck manufacturers and their customers are now using lubricants containing Moly-Sulfide additive in at least 14 different applications. These include chassis points, ball joint suspensions, torsion suspension assemblies, fifth wheels, shackle bolts, king pins, valve stems, automatic window mechanisms, wind-shield wiper mechanisms, seat adjusters, drive shaft splines.

In aircraft, Moly-Sulfide is added to aircraft greases. In jet engines under exacting conditions of temperature and pressure it is used on turbine shafts, splines and gear reduction units.

In other industries, Moly-Sulfide is being used in lubrication jobs which formerly presented serious difficulties. A Florida cement plant is using gear compound containing Moly-Sulfide to lubricate rack gears and a Michigan manufacturer uses Moly-Sulfide as an additive to drawing compounds for drawing stainless steel hub caps. In New York a baker of crackers and cookies is using Moly-Sulfide grease for lubrication of oven chains which must operate at high temperatures. In Louisiana an oil well drilling contractor is using Moly-Sulfide additive in tool joint compounds. He reports that disjointing when drilling below 15,000 feet is no problem now: no galling, welding or stripped threads.

Aircraft manufacturers are using Moly-Sulfide greases on many types of ball and joint suspension lubrication.



Oil well drilling contractors are using Moly-Sulfide additives to tool joint compounds.

Lubrication engineers are offered information and help in evaluating the use of Moly-Sulfide as an additive to lubricants by the Climax Molybdenum Co.

Currently Moly-Sulfide is being investigated by many petroleum research laboratories and lubricant users. They are interested in studying, under practical working conditions, the ability of Moly-Sulfide to increase effective lubrication.

If insuring effective lubrication is a problem facing your company, Moly-Sulfide additives may be a solution. Climax Molybdenum Company is the principal source of this product. If you need authoritative information, please get in touch with us and we will be pleased to send you literature on Moly-Sulfide and the sources of supply for experimental lubricants containing Moly-Sulfide.

Department 16
CLIMAX MOLYBDENUM COMPANY
500 Fifth Avenue, New York 36, N. Y.

Please send me the following:

Literature
1. "Moly-Sulfide, Lubricant Additive" ☐
2. "Moly-Sulfide in Chassis Grease" ☐
3. "Moly-Sulfide Specification and Properties" ☐

List of Sources for
1. Railroad Greases ☐
2. Chassis Greases ☐

Sample — One-ounce tube of Moly-Sulfide ☐

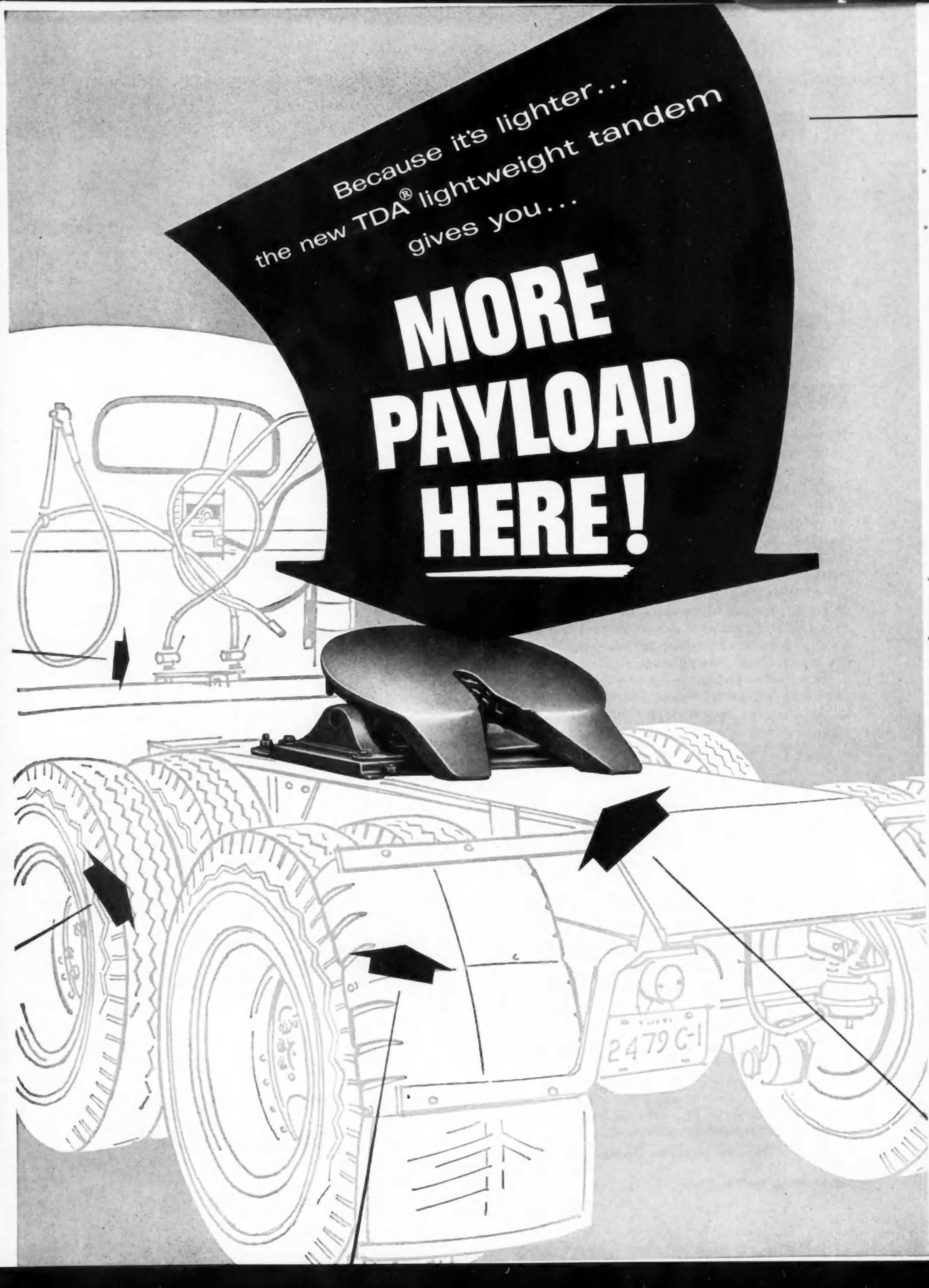
Name...

Position...

Company...

Address...

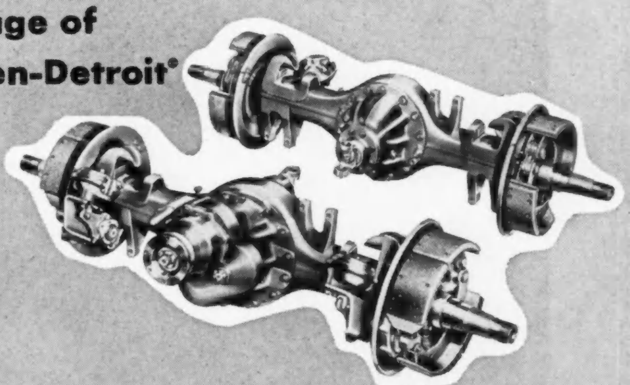
CLIMAX MOLYBDENUM


Because it's lighter...
the new TDA® lightweight tandem
gives you...
MORE
PAYLOAD
HERE!
2479 C-1

this means...

8,500 EXTRA TON-MILES PAYLOAD A YEAR

...and it's built with a high percentage of parts interchangeable with Timken-Detroit® standard single axle components



There are important *payload bonuses* for truckers in TDA's new lightweight tandem. Over 230 pounds lighter than any unit of the same capacity, this new axle assembly gives operators more than 8500 extra ton-miles of payload during an average 75,000-mile trucking year.

Important *maintenance advantages* also are gained with this new tandem. Almost all of the wearing parts—gears, pinions, differentials, bearings and brakes—are identical with components from widely used TDA standard single axles. This means easier service, smaller parts inventory, and more time on the road.

Some Outstanding Features of this New Timken® Tandem

TDA Inter-Axle Differential divides torque evenly between axles . . . yet permits wheels of one axle to revolve faster or slower than wheels of the other axle. This means both axles are doing equal amounts of work . . . driving parts and tires last longer.

Driver-Controlled Lockout—with TDA Inter-Axle Differential, the driver can obtain the advantages of straight-through drive under slick or icy conditions by locking out the differential at any driving speed.

Big, Dependable Hypoid Gears rotate in conventional direction for maximum gear and bearing life.

Optional Axle Connecting Groups. This new tandem is available with either TDA famous "Cradle Ride" axle connecting parts, or brackets to accept other approved chassis hook-ups.

This new tandem insures new payload profits, faster, easier service and operating economies for operators everywhere. For complete information contact your nearest vehicle dealer or branch.

TIMKEN *Detroit* AXLES

TIMKEN-DETROIT AXLE DIVISION
ROCKWELL SPRING AND AXLE COMPANY
DETROIT 32, MICHIGAN

The Accepted TDA Standard
TRADE MARK REGISTERED

WORLD'S LARGEST MANUFACTURER OF AXLES FOR TRUCKS, BUSES AND TRAILERS

Plants at: Detroit, Michigan • Oshkosh, Wisconsin • Utica, New York • Ashtabula, Kenton and Newark, Ohio • New Castle, Pennsylvania

Send for Free Print—1900 De Dion-Bouton Motorette.
This print from the file of P. S. de Beaumont, not for commercial use.

The De Dion-Bouton is remembered today for the De Dion axle, a frame that contained the differential, which more recently many racing and sports car models have adopted. This model also employed a one-cylinder engine mounted in the rear with automatic intake valve. This is one of a series of antique automobile prints that will appear in future Morse advertisements. Write for your free copy, suitable for framing, to: MorseChainCompany,Ithaca,NewYork.

Why Morse Timing Chains are original equipment on 18 out of 22 automobiles

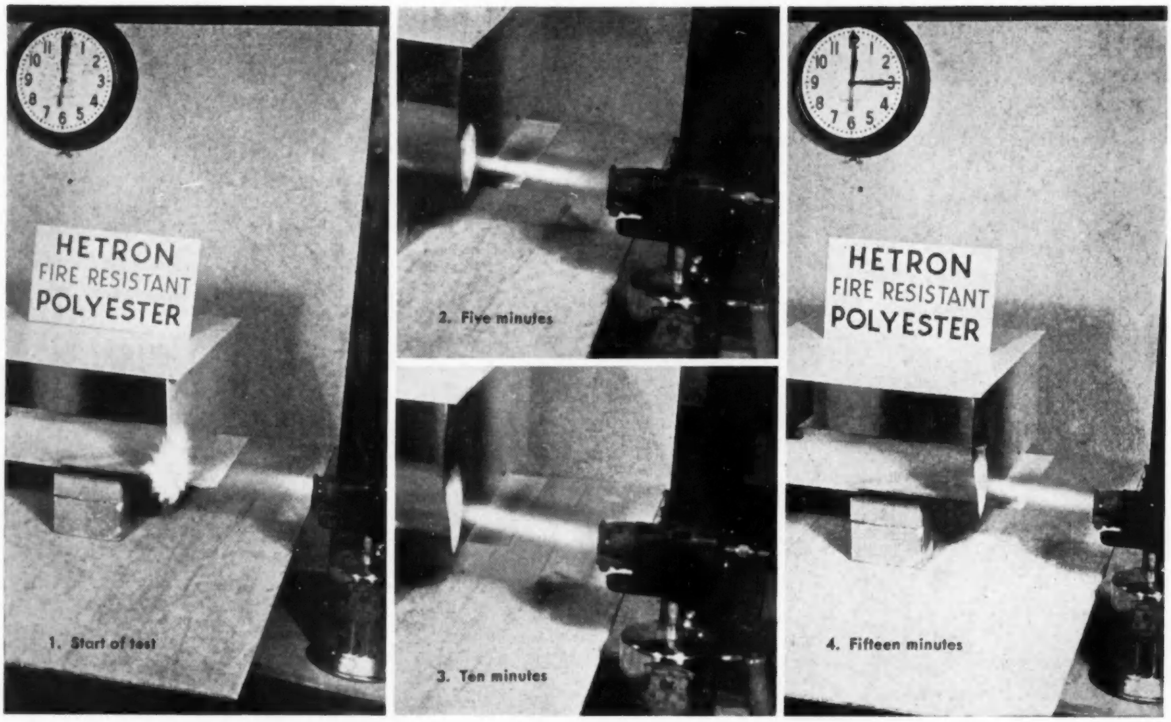
Morse Timing Chain Drives are now specified as original equipment on eighteen out of twenty-two makes of automobiles. This is true for several reasons:

(1) Morse Timing Chain Drives assure car, bus, and truck manufacturers of long, trouble-free service life—eliminate maintenance difficulties. (2) Morse Timing Chain Drives offer safe, quiet, and smooth operation, even when camshafts and crankshafts are not exactly parallel. (3) Speedy delivery of a complete line of timing chain drives helps to meet production schedules. (4) Morse offers expert engineering service to assist in solving automotive timing chain problems of design, development, and application.

Check with Morse on your timing chain problems. Find out, too, how well other Morse Power Transmission Products can answer your needs in product design and application. MORSE CHAIN COMPANY, ITHACA, NEW YORK.

MORSE

CHAINS, CLUTCHES, AND COUPLINGS



BLOWTORCH FLAME plays steadily on HETRON test structure for 15 minutes; can't start it burning.

New material for idea-men: **fire-resistant polyesters**

Want to engineer high strength plus *specific fire resistance* into a product? Take a hard look at HETRON® polyester resins.

You can use HETRON in many places where reinforced polyesters have not been practical heretofore. HETRON will not burn, except at the point where a hot flame is directly applied. It "snuffs out" as soon as the flame source is removed.

In exploratory tests, sheets of HETRON have shown flame spreads as low as 20 by ASTM E84-50T (Tunnel Test)—compared with ratings of 0 for asbestos board and 100 for red oak.

The versatile "family" of HETRON resins can be modified and blended by the fabricator, to make possible a whole galaxy of controlled physical properties. These resins combine fire resistance with outstanding flexural strength, tensile strength, heat resistance, and very low water absorption. Using light-stabilized HETRON, you can attain excellent resistance to weathering.

Some HETRON resins, including semi-rigid HETRON 32A, are manufactured to meet Military Aircraft Specification MIL-R-7575A, Types I and II. HETRON 92, with up to 10% added styrene, meets MIL-R-7575A, Types I, II, III.

New as it is, HETRON is already proving its merit in automobile and truck body panels and structural members; aircraft parts; large boat hulls; machine housings; radomes; electrical insulating board and parts; chemically resistant blowers, tanks and ductwork; "sandwich" structural and refrigeration panels; skylights, louvers, and industrial windows.

Is there a place in your designs for this unique combination of strength-plus-safety? To find out, write today for complete data file on HETRON resins.

Ask also for names of fabricators who can supply you with HETRON parts.

Comparative Physical Characteristics

HETRON and 10 non-fire-resistant resins

Physical Property		Rigid Resins		Semi-rigid Resin
		HETRON 92	Avg. 10 Others	HETRON 32 A
Flexural Strength, PSIx10³	Room Temp.	38.6	36.4	41.8
	180°F.	25.0	18.6	23.5
Flexural Modulus, PSIx10⁶	Room Temp.	1.88	1.61	1.82
	180°F.	0.90	0.79	0.85
Tensile Strength, PSIx10³		21.7	22.0	21.0
Water Absorption, Pct. by Wt.		0.13	0.29	0.13

SUPERIOR PHYSICALS of HETRON show up in exhaustive tests by independent, impartial laboratories. Panels 0.1" thick, made from HETRON and 10 leading non-fire-resistant resins, contained 35-40% glass mat, 17-20% filler, and the balance resin. Note that HETRON 32A, a semi-rigid resin, is compared with non-fire-resistant *rigid* resins.

HOOKER CHEMICALS

From the Salt of the Earth

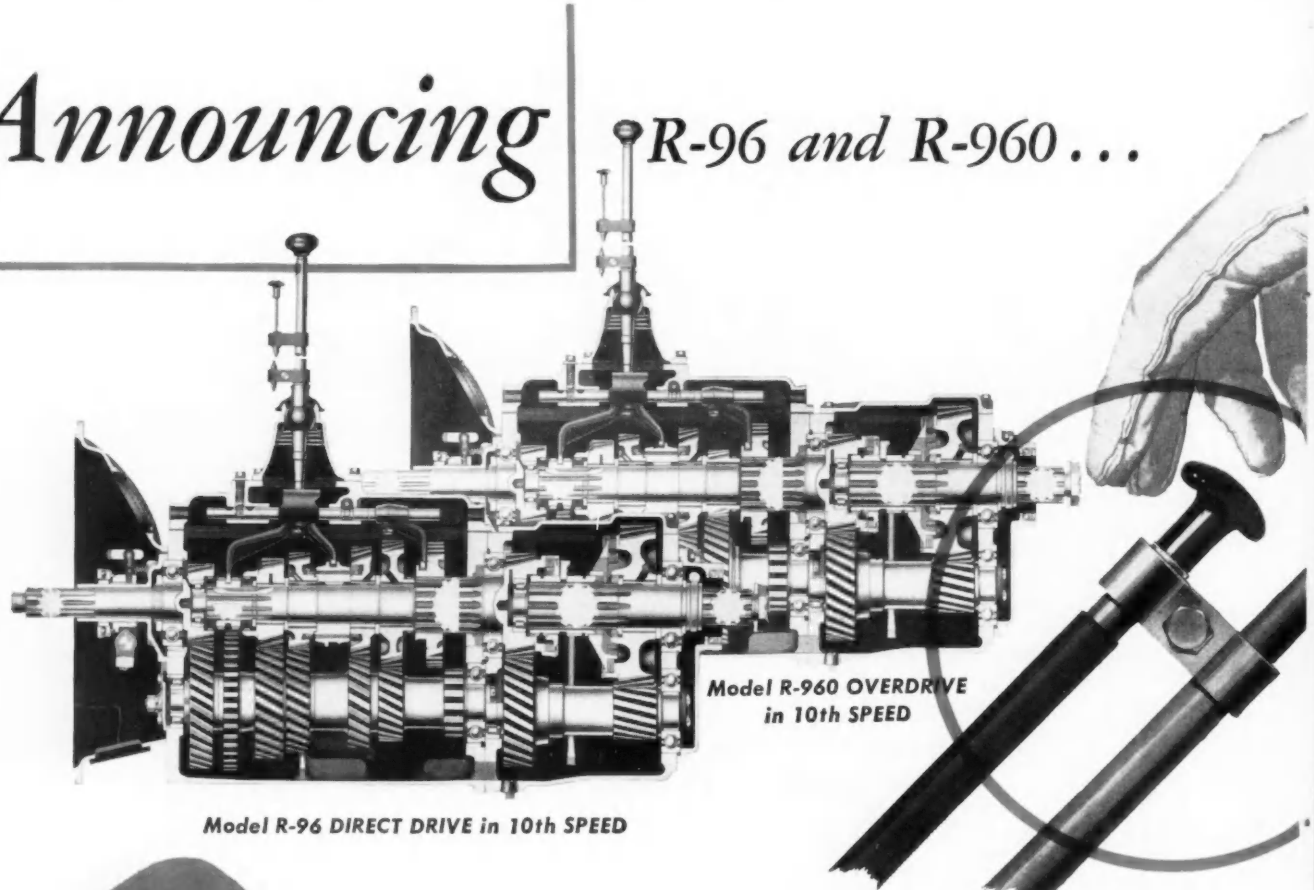
HOOKER ELECTROCHEMICAL COMPANY

38 FORTY-SEVENTH ST., NIAGARA FALLS, N. Y.

NIAGARA FALLS · TACOMA · MONTAGUE, MICH. · NEW YORK · CHICAGO · LOS ANGELES

S-2083

Announcing R-96 and R-960...



2 *New, shorter, lighter ...*

Fuller semi-automatic

Fuller now offers for the first time... Models R-96 and R-960 Semi-Automatic RoadRanger Transmissions with 10 forward and 2 reverse speeds.

With increased performance through exclusive operational features found in *no* other transmission ... this new 96 series provides all the advantages of the 6 year old 95 series PLUS SHORTER LENGTH AND LIGHTER WEIGHT . . . the new models are 2½" shorter, and weight has been reduced 60 lbs.

No gear splitting . . . there are 10 selective ratios evenly and progressively spaced averaging short 28% steps. Higher road speeds are possible because the engine operates in peak hp range . . . resulting in greater fuel economy.

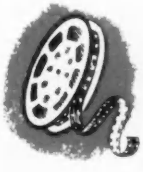
There's less driver fatigue because there are 1/3 less shifts. Range shifts are pre-selected, automatic and synchronized. More cargo can be carried on the payload axles.

RoadRangers Give Complete Control

Truck drivers have the skill, ability, experience and fast coordination to anticipate ratio requirements from what they see on the road ahead. They can and will provide the right ratios in time, if given the equipment which will permit them to act within those few critical moments before engine rpm and torque drop. But, if they have to wrestle it out with a two-stick main and auxiliary—or sit waiting for automatic actuation—they cannot be blamed for high ton-mile costs.

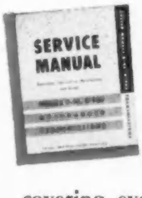
With the new Semi-Automatic RoadRanger Transmissions, the driver has complete control of the situation. He can select ratios as required, exactly as his experience tells him is best.

Shifting up, or down, or skip-shifting in either direction, drivers find the new Fuller R-96 and R-960 All-Air Shift RoadRangers the most efficient transmissions available . . . the answer to the problem of the right-ratio-at-the-right-time—the answer to the flexibility of operation required



New Movie Available

A new 16 mm. sound and color film: "Semi-Automatic RoadRanger Transmissions," just released by Fuller, is a dramatic picture story showing actual operating scenes, and how to operate Semi-Automatic RoadRanger Transmissions. It is being distributed free through truck dealers and distributors.



Instructions — Service

Fuller Manufacturing Company has prepared a 76-page Service Manual containing 232 illustrations covering every detail of operation, lubrication, maintenance and repair of these models. Shifting instructions, condensed on illustrated tags for the R-96 and R-960 Models are supplied for attaching to the shift lever.

GEAR RATIOS

	R-96	% Step	R-960	% Step	
Tenth	1.00	27	.78	28	High Range
Ninth	1.27	29	1.00	27	
Eighth	1.64	28	1.27	29	
Seventh	2.10	30	1.64	28	
Sixth	2.73		2.10		
RANGE SHIFT		30		31	
Fifth	3.54	27	2.76	28	Low Range
Fourth	4.48	29	3.54	27	
Third	5.80	28	4.48	29	
Second	7.43	30	5.80	28	
First	9.65		7.43		
Low Reverse	11.26		11.26	Low Range	
High Reverse	3.18		3.18	High Range	
Weight					767 lbs.
Oil Capacity					33 pts.

10-speed ROADRANGERS®

to meet every varying condition of traffic, time and terrain.

Two New RoadRangers — Shorter length...weigh less

The 10 speeds are 2½" shorter in length than the older 95 series models, and weight reduction makes the new 96 series 60 pounds lighter. By replacing only 5 parts, the R-96 RoadRanger can be converted to the overdrive model.

Both new models consist of two sections—a 5-speed transmission with closely spaced ratios, and a 2-speed auxiliary with wider spaced ratios. The combination provides ten forward speeds and two reverse speeds shifted by one lever. The ten forward speeds are secured by using the ratios of the 5-speed section twice . . . the first time with the auxiliary section in low gear; the second time with it in high gear. The two reverse speeds are secured by using reverse in the 5-speed section through either high or low gear of the auxiliary section. The 10 selective ratios of the new RoadRangers are evenly and progressively spaced in short 28% steps. Range shifts are pre-selected, automatic and synchronized.

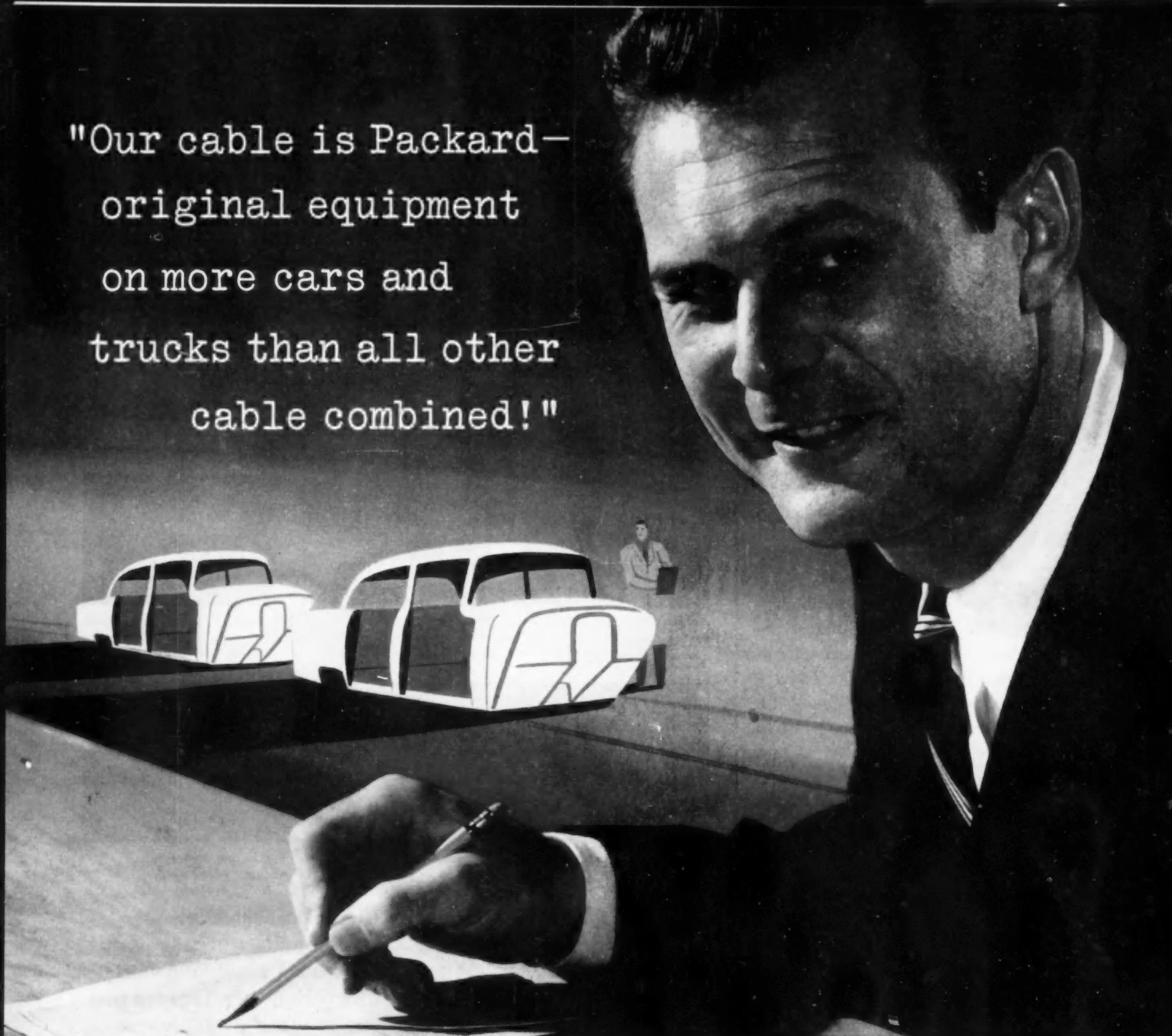
Automatic Air Shift

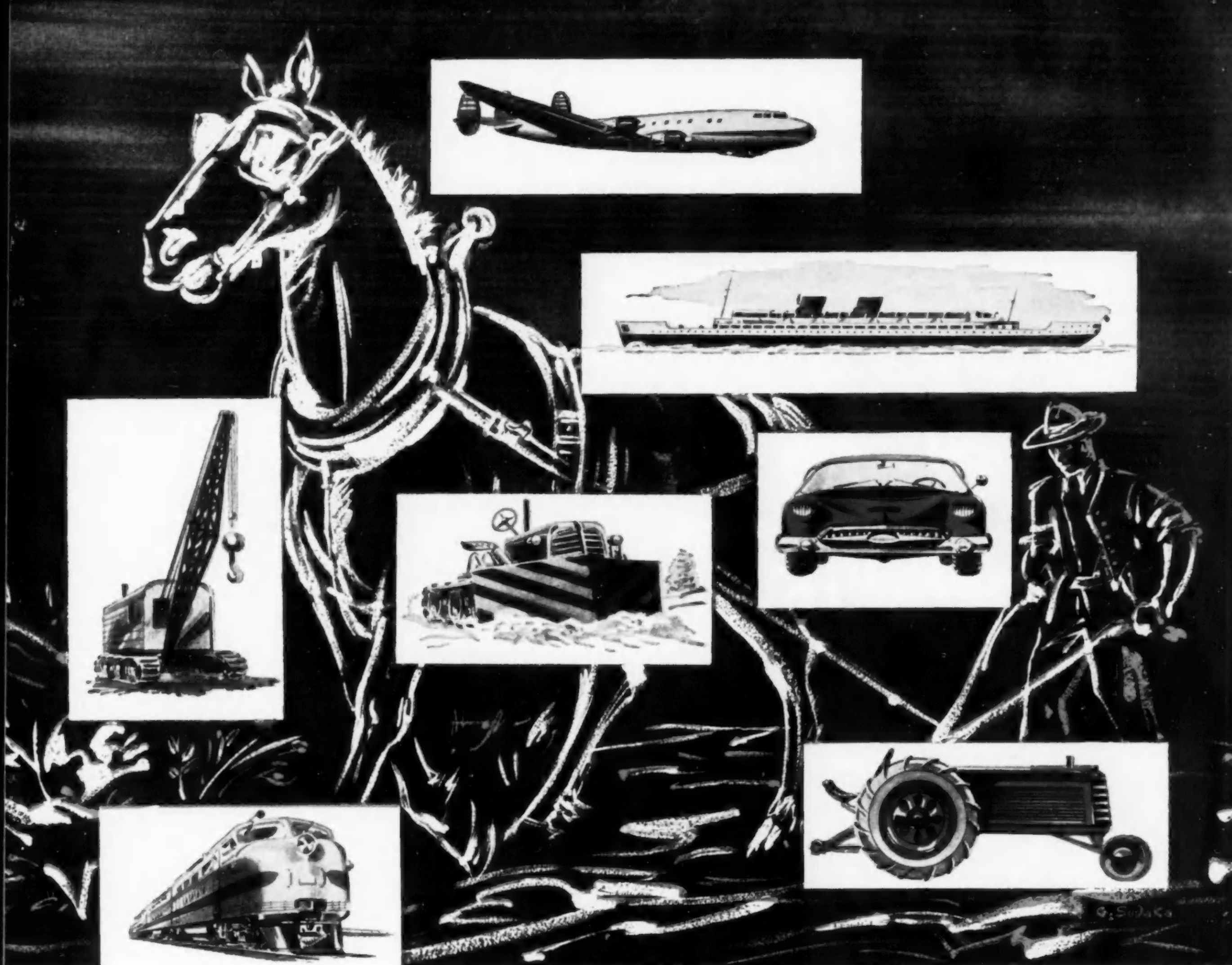
The auxiliary section is automatically shifted by air after pre-selection of the operating range required. The automatic shift in the auxiliary section after pre-selection is always accompanied by a four-step shift in the 5-speed transmission, either up or down depending upon the direction of the shift in the auxiliary.

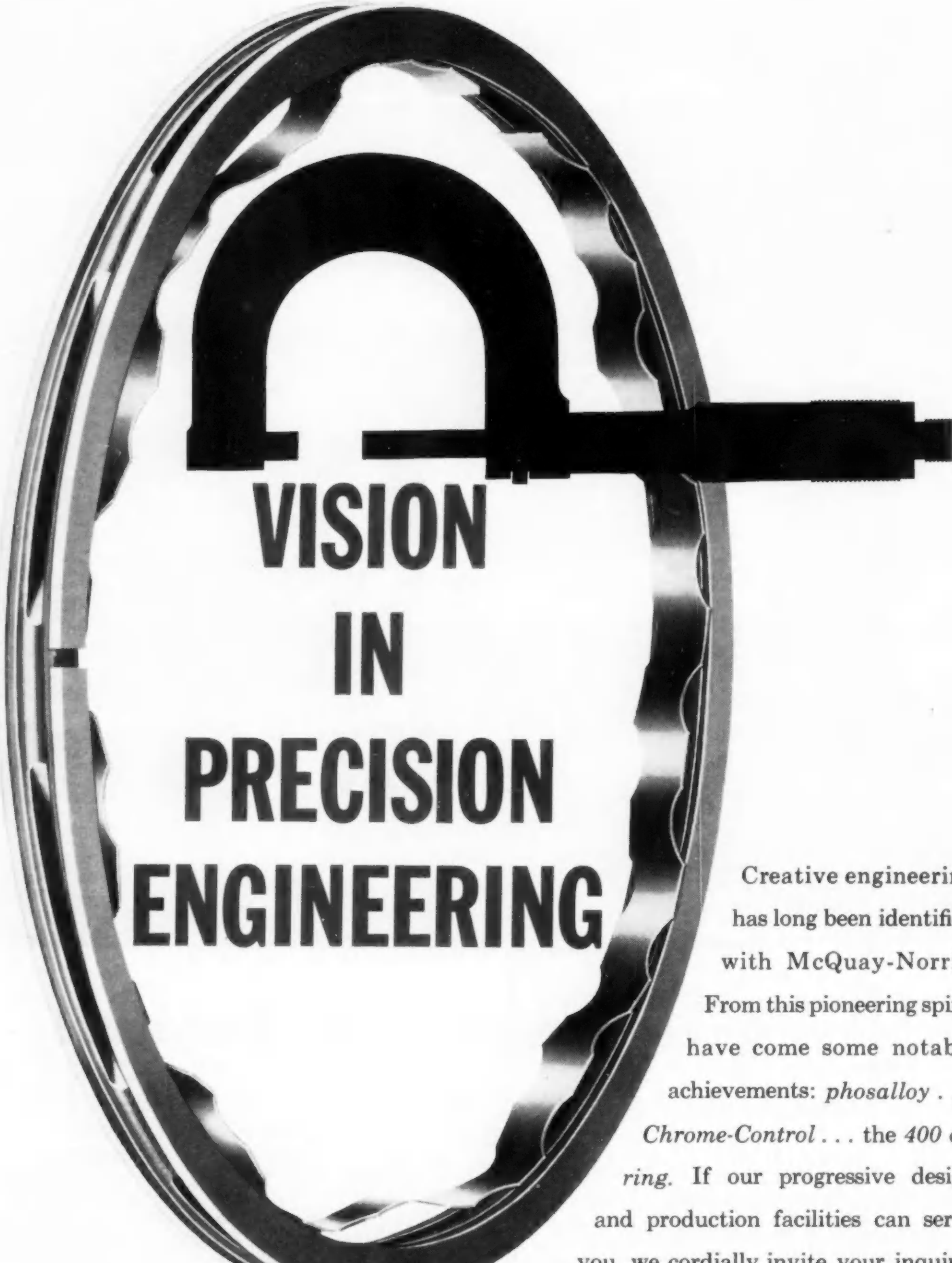
Specify the brand new R-96 and R-960 Fuller Semi-Automatic RoadRanger Transmissions *by name.* Assure *faster* trip time, *lower* fuel consumption, *longer* engine life, *less* driver fatigue . . . *greater profits.* Check with your local truck dealer for the most efficient, easiest-shifting Fuller Transmission models to meet your specific trucking requirements.

Fuller Manufacturing Company
Transmission Division
KALAMAZOO, MICHIGAN

Unit Drop Forge Div., Milwaukee 1, Wis. • Shuler Axle Co., Louisville, Ky. (Subsidiary) • Sales & Service, All Products, West. Dist. Branch, Oakland 6, Cal. and Southwest Dist. Office, Tulsa 3, Okla.


"Our cable is Packard—
original equipment
on more cars and
trucks than all other
cable combined!"





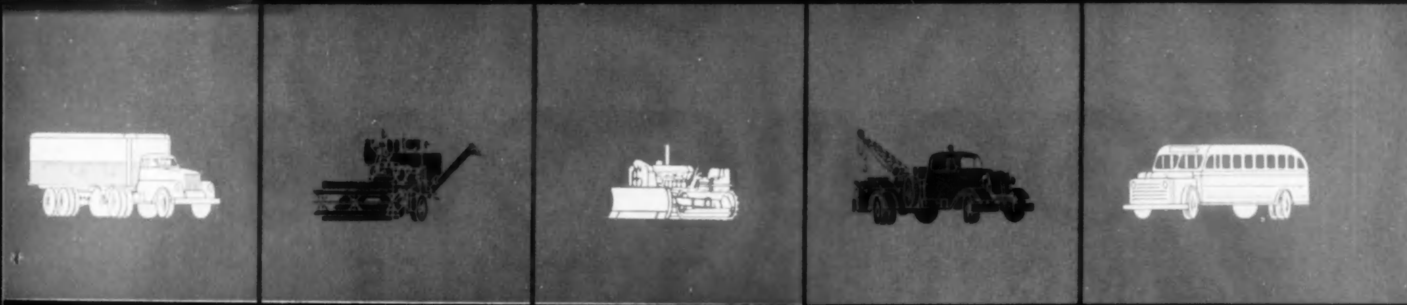
VISION IN PRECISION ENGINEERING

Creative engineering has long been identified with McQuay-Norris. From this pioneering spirit have come some notable achievements: *phosalloy* . . . *Chrome-Control* . . . the *400 oil ring.* If our progressive design and production facilities can serve you, we cordially invite your inquiry.

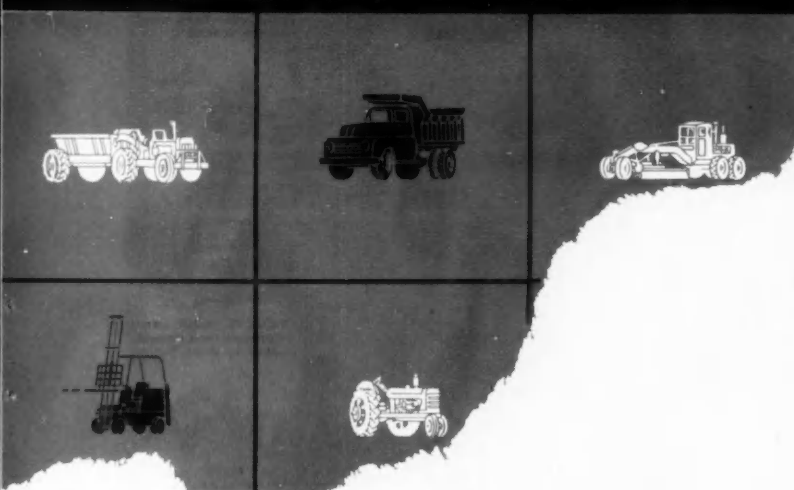
McQUAY-NORRIS

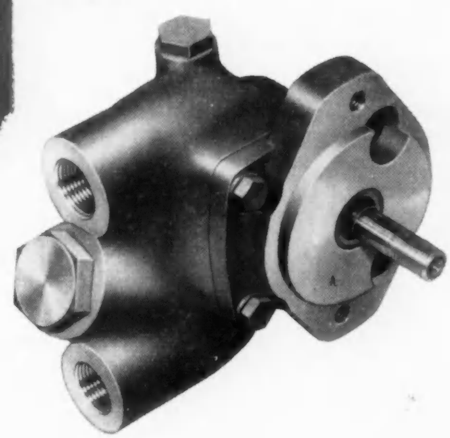
PISTON RINGS . . . HARDENED AND GROUND PARTS

McQUAY-NORRIS MANUFACTURING COMPANY
ST. LOUIS 10, MISSOURI



Helping to put the POWER in Power Steering for Trucks, Buses, Tractors, Construction Equipment





When it comes to power steering, heavy duty over-the-road and off-the-road vehicles have special requirements. Components have to be huskier, tougher, able to stand up under the constant demands of heavy duty operation.

To provide unfaltering hydraulic power regardless of operating conditions, Borg-Warner's Pesco Products Division has developed a remarkable power steering pump. An engine-driven, positive-displacement gear pump specially designed for heavy duty equipment, it features Pesco's exclusive "Pressure Loaded" bearings which automatically adjust for wear . . . minimum power requirements . . . minimum size . . . weight of only 6.75 pounds . . self-lubrication . . . built-in pressure relief valve with standard setting of 750 psi.

Like all Borg-Warner products, the Pesco power steering pump was born of B-W's "design it better—make it better" tradition. In this way Borg-Warner serves industry with both creative engineering and large-scale precision production.

B-W Engineering Makes It Work

B-W Production Makes It Available

ENGINEERING B-W PRODUCTION

185 products in all are made by

BORG-WARNER

THESE UNITS FORM BORG-WARNER, *Executive Offices, 310 S. Michigan Ave., Chicago.* **DIVISIONS:** ATKINS SAW • BORG & BECK • BYRON JACKSON CALUMET STEEL • DETROIT GEAR • FRANKLIN STEEL • HYDRALINE PRODUCTS • INGERSOLL CONDITIONED AIR • INGERSOLL KALAMAZOO • INGERSOLL PRODUCTS • INGERSOLL STEEL • LONG MANUFACTURING • MARBON CHEMICAL • MARVEL-SCHEBLER PRODUCTS • MECHANICS UNIVERSAL JOINT NORGE • PESCO PRODUCTS • ROCKFORD CLUTCH • SPRING DIVISION • WARNER AUTOMOTIVE PARTS • WARNER GEAR • WOOSTER DIVISION **SUBSIDIARIES:** B-W ACCEPTANCE CORP • BORG-WARNER INTERNATIONAL • BORG-WARNER, LTD • BORG-WARNER SERVICE PARTS • LONG MFG., LTD MORSE CHAIN • MORSE CHAIN OF CANADA, LTD • REFLECTAL CORP • WARNER GEAR, LTD • WESTON HYDRAULICS, LTD

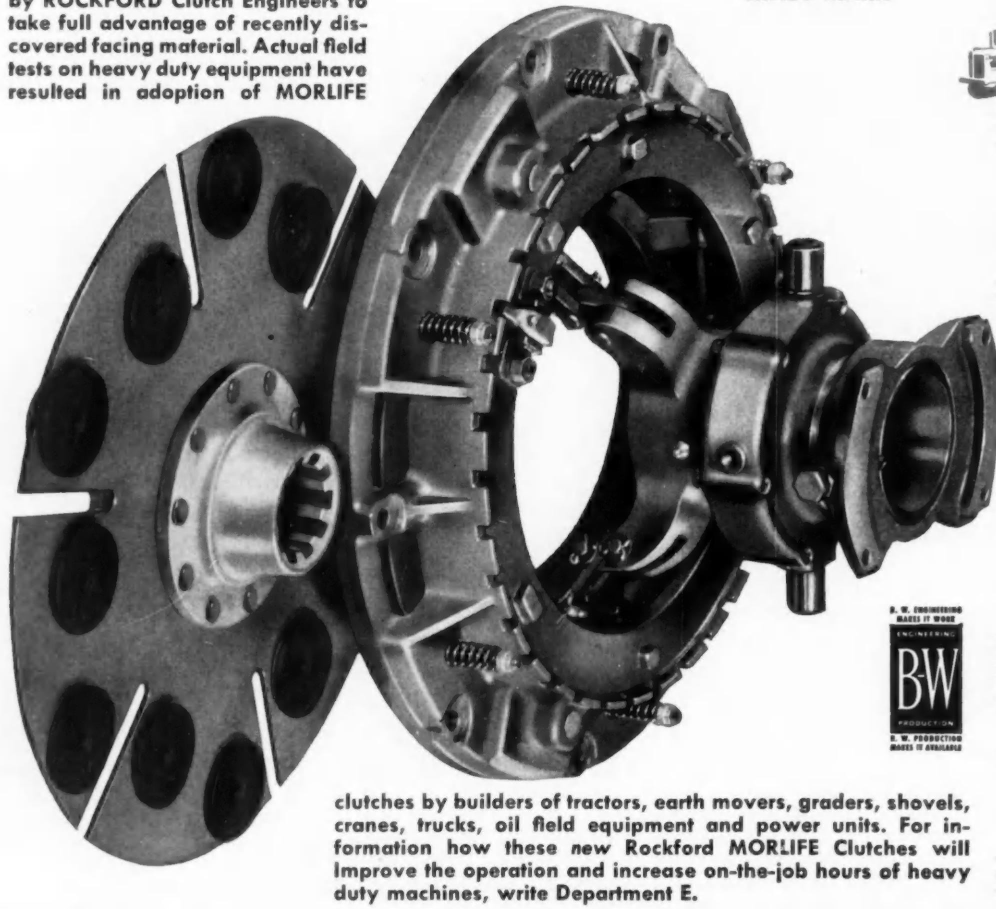
ROCKFORD

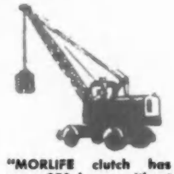
New MORLIFE* CLUTCHES and CLUTCH PLATES Give—

MORE Clutch Life (400% MORE)
MORE Torque Capacity (100% MORE)
MORE Heat Resistance (50% MORE)

These new ROCKFORD Clutches and Clutch Plates have been developed by ROCKFORD Clutch Engineers to take full advantage of recently discovered facing material. Actual field tests on heavy duty equipment have resulted in adoption of MORLIFE clutches by builders of tractors, earth movers, graders, shovels, cranes, trucks, oil field equipment and power units. For information how these new Rockford MORLIFE Clutches will Improve the operation and increase on-the-job hours of heavy duty machines, write Department E.

*TRADE MARK





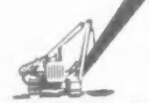
"MORLIFE clutch has gone 851 hours without slipping or adjustment."

"MORLIFE clutch going strong after 1695 hours, working in sand."

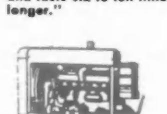
"MORLIFE clutches last 950 hours longer, without adjustment."

"MORLIFE clutch needs adjustment once a month, instead of daily."

"MORLIFE requires lighter handle pull and one tenth the adjustments."



"MORLIFE requires lighter handle pull and one tenth the adjustments." "MORLIFE pulls harder and lasts six to ten times longer."

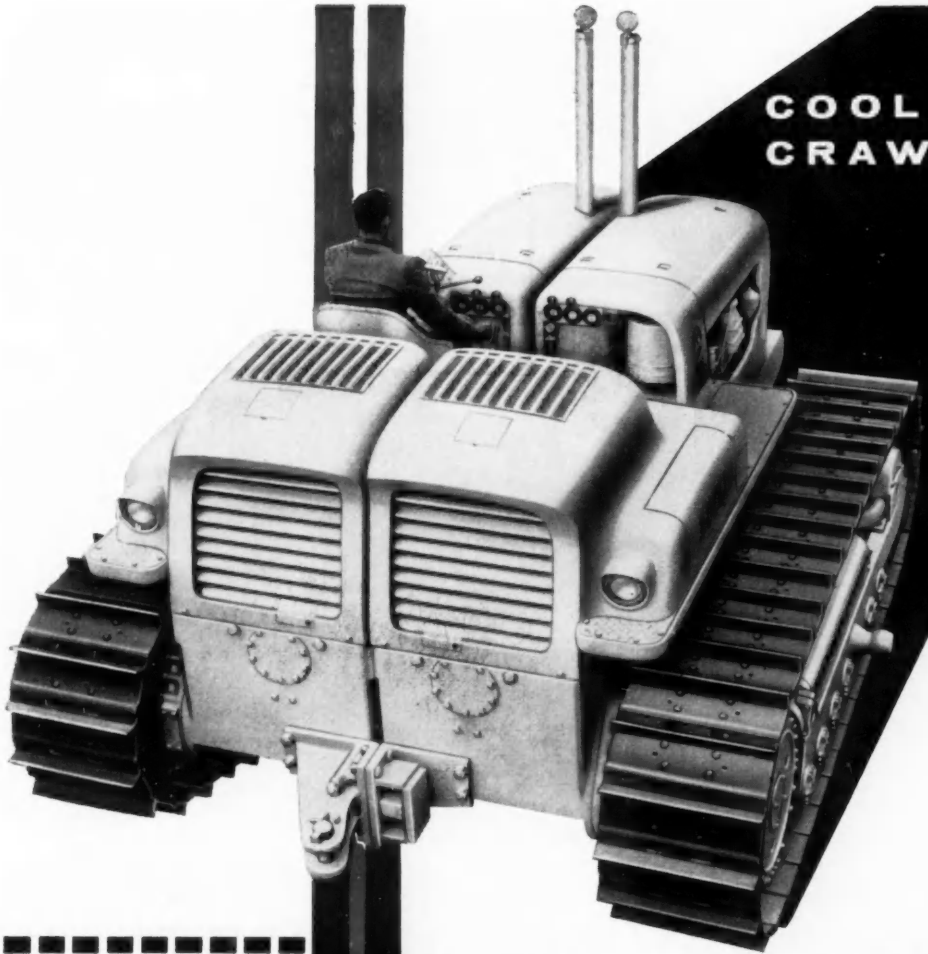


"Won't buy a unit that isn't equipped with Durable MORLIFE clutch."

ROCKFORD Clutch Division BORG-WARNER

316 Catherine Street, Rockford, Illinois, U.S.A.

CLUTCHES



COOL CRAWLER

"EUC" TC-12 Handles Any Job . . . And Harrison Handles The Heat!

This Twin Crawler takes it cool . . . as Harrison cracks down on the heat! Pulling heavy construction equipment or moving the earth at top speeds . . . Harrison holds the line on heat. That's why Euclid specifies Harrison oil coolers. They know that for the long haul Harrison heavy-duty, high-capacity cooling equipment can't be beat. They know from long experience that Harrison products are engineered and built for dependable, durable, economical service. In fact, Harrison heat control products are backed by more than 45 years of research and manufacturing experience. If you have a cooling problem, look to Harrison for the answer.

GM GENERAL MOTORS

TEMPERATURES MADE TO ORDER

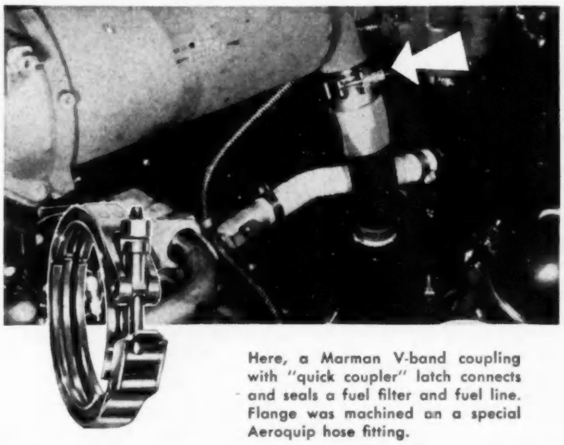
HARRISON

RADIATOR DIVISION, GENERAL MOTORS CORP., LOCKPORT, N.Y.

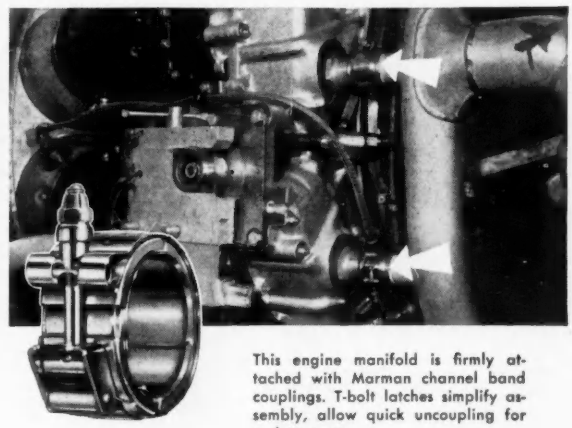
Marman Stainless Steel Straps, Clamps and Couplings Solve Fastening and Joining Problems

To assemble components, join lines and ducts, or fasten and support accessories, use Marman products for utmost simplicity and greater versatility. Pictured below are four examples of Marman clamps, straps and couplings designed for airframe and engine manufacturers.

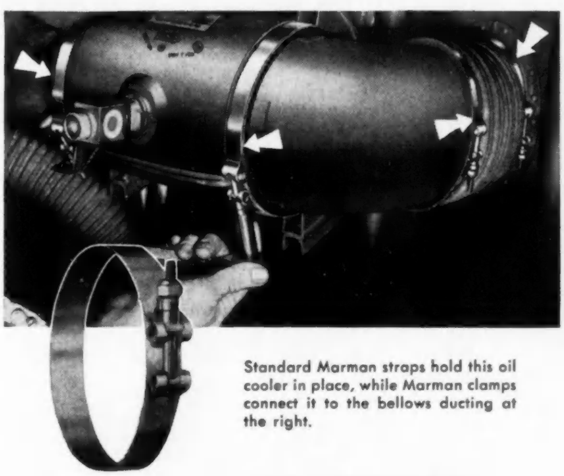
Marman's highly qualified engineering service is ready to assist you, too. Call, wire or write us for full information.



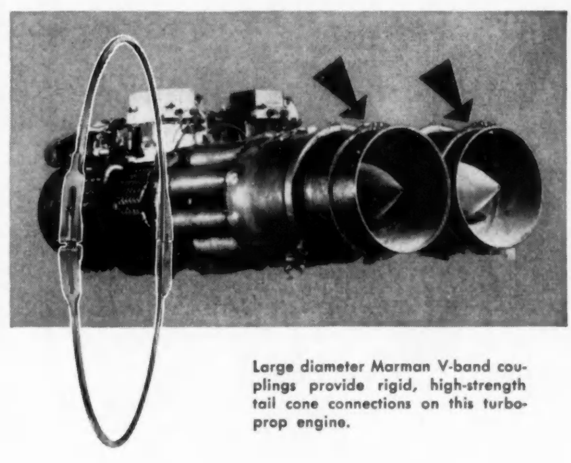
Here, a Marman V-band coupling with "quick coupler" latch connects and seals a fuel filter and fuel line. Flange was machined on a special Aeroquip hose fitting.



This engine manifold is firmly attached with Marman channel band couplings. T-bolt latches simplify assembly, allow quick uncoupling for maintenance.



Standard Marman straps hold this oil cooler in place, while Marman clamps connect it to the bellows ducting at the right.



Large diameter Marman V-band couplings provide rigid, high-strength tail cone connections on this turboprop engine.

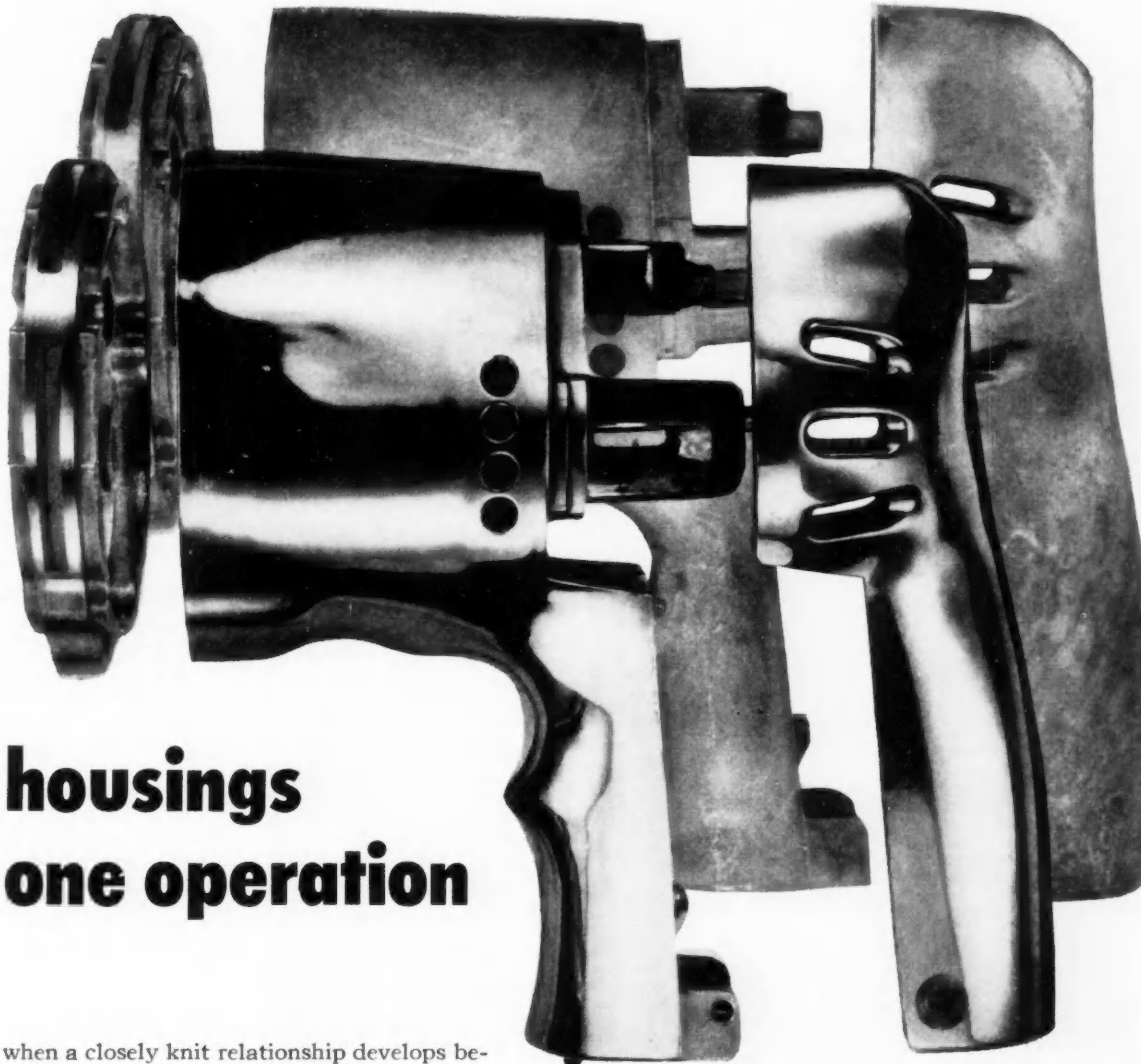
MARMAN PRODUCTS COMPANY, INC.

A SUBSIDIARY OF Aeroquip CORPORATION

11214 EXPOSITION BLVD., LOS ANGELES, CALIFORNIA

IN CANADA: AEROQUIP (CANADA) LTD., TORONTO 15, ONTARIO

MARMAN PRODUCTS ARE MANUFACTURED UNDER VARIOUS U.S., CANADIAN AND FOREIGN PATENTS AND OTHER PATENTS PENDING



housings one operation

when a closely knit relationship develops between engineers of two companies over many years of product development.

Hardly a Black and Decker tool has not benefited in one way or another from this fruitful relationship. From it has come lighter weight, higher precision, increased strength, simplified and lower cost production, many performance improvements. And Black and Decker takes full advantage of the flexibility of die castings to provide extra sales features and aid economy.

Maybe this is the time for you to do as companies like Black and Decker, Singer, AMF, Underwood, York, and many another have done...time to initiate a profitable business and engineering relationship based on the use of Doehler-Jarvis die castings.

Doehler-Jarvis Division

of

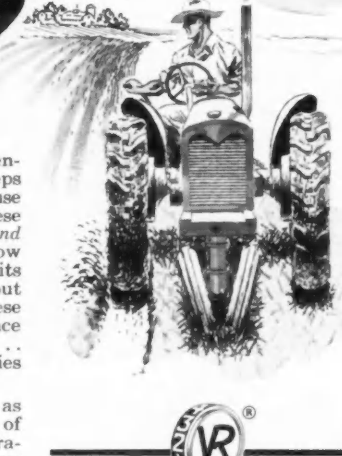
National Lead Company

General Offices: Toledo 1, Ohio

For every engine,
there's a

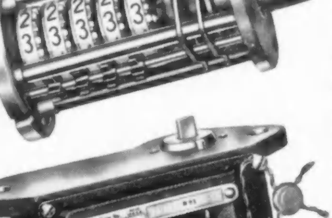
VEEDER-ROOT REV-COUNTER

to prove your product's claims



Rev-Counter for general built-in use. Self-contained case is designed for outside application.

Rev-Counter especially designed for installation in user's housing.



Rev-Counter especially designed for built-in installations.

That's right . . . you can build into your engine a real "performance-prover" that keeps a faithful and complete record of engine use . . . a record that's beyond dispute. These Veeder-Root Rev-Counters *show you and your customers*, at any time, exactly how your equipment is performing up to its guarantee . . . whether they're getting out of it all the service you built into it. These direct counter-readings also show at a glance when routine maintenance is coming due . . . whether servicing is needed . . . and supplies other valuable facts-in-figures.

This 2-way protection is vital not only as a built-in feature of engines, but also of generators, compressors, heaters, refrigerators, high-speed cameras, and what have *you?*

Veeder-Root Rev-Counters are available with *tachometer take-off* . . . and may be geared to your own engine requirements. Count on Veeder-Root for any assistance you need in designing these Rev-Counters into your product. Write:

VEEDER-ROOT INC., Hartford 2, Conn.

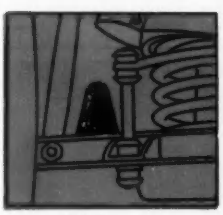
Everyone Can Count on

VEEDER-ROOT

"The Name that Counts"

In over 100 places, Enjay Butyl rubber parts

add to Pontiac performance



Axle bumper

Body seals, gaskets, insulators, pads, grommets, etc.

Brake and accelerator pedal pads, bellows

Radiator and heater hoses, ducts

Gearshift lever cover

Pontiac has been using parts made of Enjay Butyl since 1946. The great '56 model now incorporates more than 100 parts made from this super-durable rubber, adding to its performance, style and value. These parts have amazing resistance to deterioration and will easily last the life of the car.

Among the many advantages of Enjay Butyl are *price* and *ready availability*. And it is now available in non-staining grades for white and light-colored parts. Extensive laboratory and testing facilities are at your service. For the full story, contact the Enjay Company today.

ENJAY
BUTYL

Enjay Butyl is the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture

ENJAY

ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.
District Office: 11 South Portage Path, Akron 3, Ohio

36 SUCCESSFUL YEARS OF LEADERSHIP IN SERVING INDUSTRY

produce more powerful engine

Automotive engineers have known for years that they can rely on tough, leakproof Bundyweld Tubing for vital tubing parts in both cars and trucks. That's why you'll find extra-sturdy Bundyweld being used for countless important applications, like the push rods shown here.

In fact, Bundyweld has proved itself so dependable that it has racked up this almost incredible record: *Bundyweld is used in 95% of today's cars, in an average of 20 applications each.*

Here's why you, too, may profit by relying on Bundyweld for your important automotive, truck, or farm equipment applications . . . .

The tubing itself: Bundyweld is the only tubing double-walled from a single metal strip, with exclusive Bundy-developed beveled edges. It's SAE 1010 steel, copper-bonded through 360° of double-walled contact into a strong, lightweight, beadless tubing. Wall thickness and concentricity are accurate, uniform. Ultimate yield strength, tensile strength, and fatigue limit are exceptionally high.

Bundy's plus-services: Bundy backs up its unparalleled tubing with a staff of engineering experts who take pride in solving customers' tricky tubing problems; with unexcelled fabrication services; with custom-packaging of orders, *on-schedule* deliveries.

For more information, or for help with your special tubing problems, call, write, or wire us.

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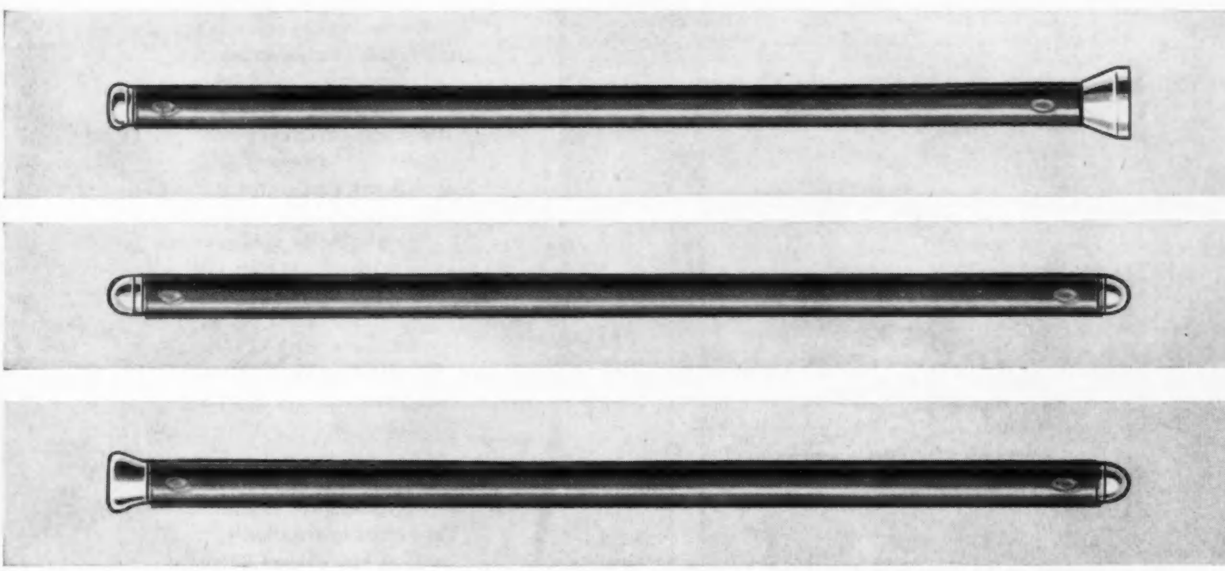

Bundy Tubing fabricates more easily than the material it replaces; results in more uniform, better finished parts. Push rods above were fabricated by Chicago Screw Company, Bellwood, Ill.

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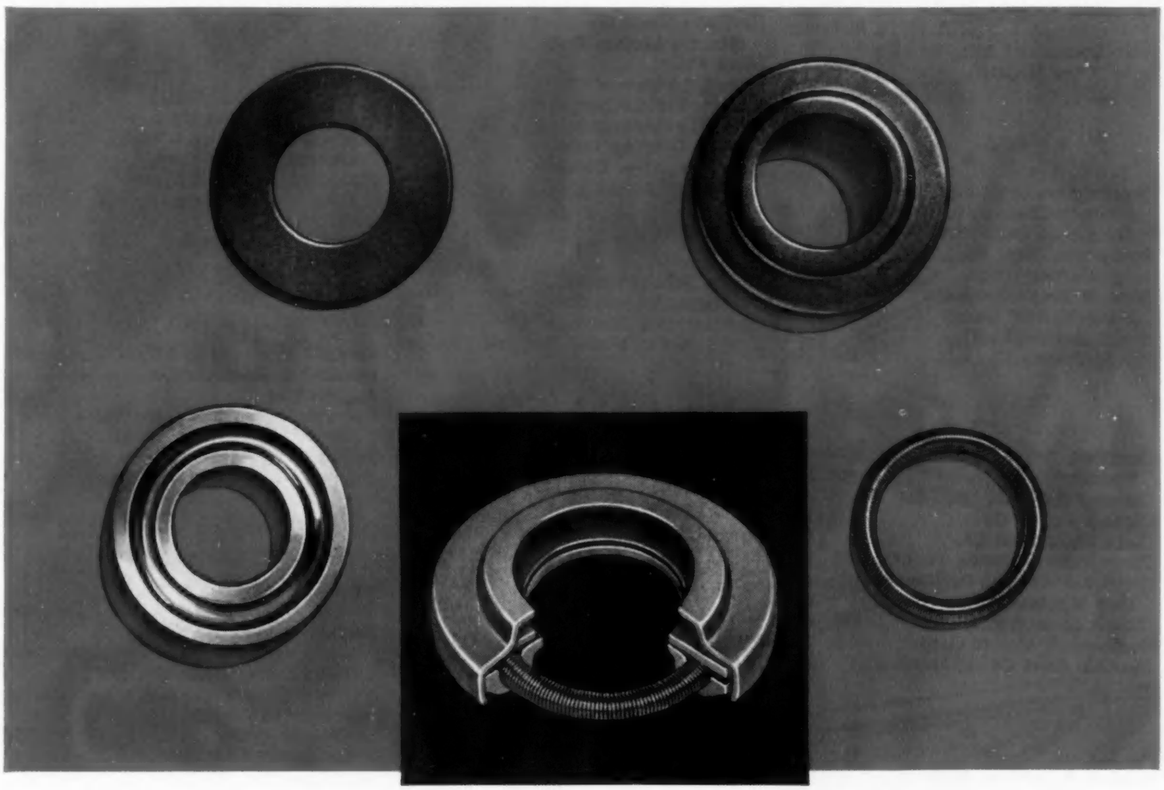

Now you can give your engines *positive* valve rotation at lowest possible cost.

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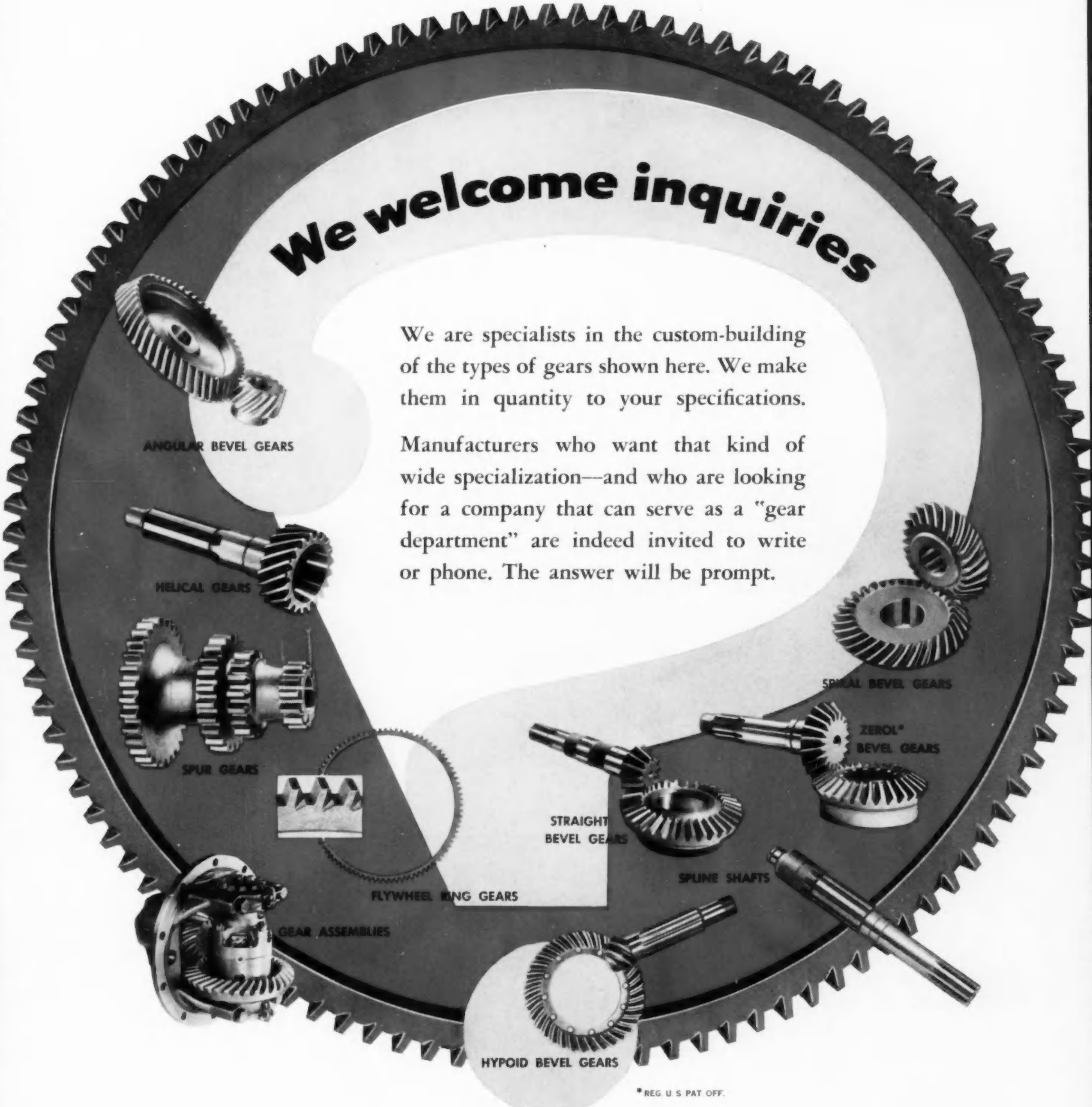

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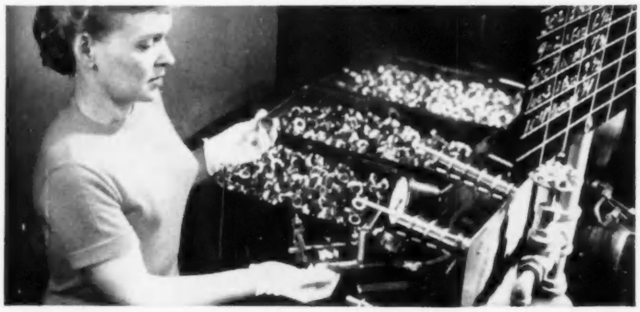
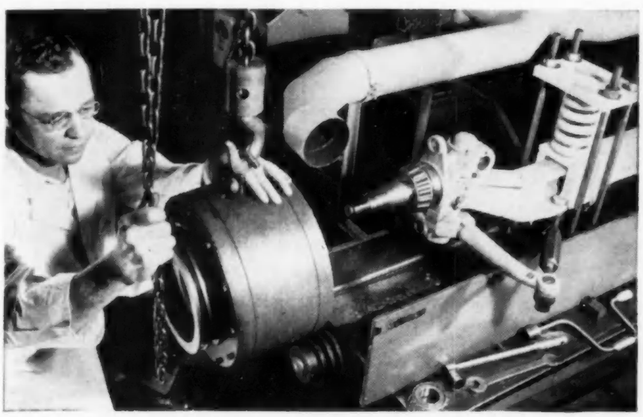
LM11949 ON THIS BEARING CONE, and LM11910 on the cup, identify it as a new low-cost, space-saving tapered roller bearing for front wheels. But with the trade-mark "Timken" also on the bearing, the number has a history of extra quality and service, tells you the bearing was made by the originator of the new design.

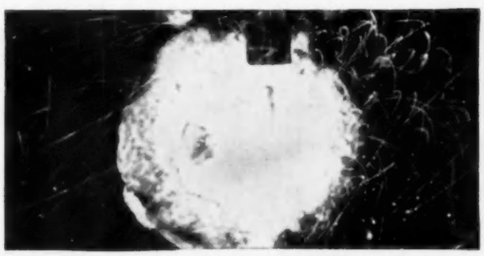


SHE USES THIS MACHINE to measure bore size and roundness of Timken® bearing cones in ten-thousandths of an inch. Cones are then sorted into sub-sizes by O.D. and matched with rollers that have also been sub-sized. It's this precision manufacture that pays off in longer life, less maintenance.



WE MAKE SPECIAL TESTS to help automobile manufacturers solve basic design problems. In this simulated service test, we run front-axle assemblies under maximum loads. It tests the bearings under operating loads, compares seals and lubricants, shows customers how to get longer bearing life.

WE CASE-HARDEN EVERY RACE AND ROLLER in the world's largest battery of case-carburizing furnaces. We make bearing parts hard on the outside to resist wear, tough on the inside to take shock. It's another reason Timken bearings are number-one for value in your car's moving parts—the vital zone.



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